
Final

North Hollywood Operable Unit Chromium Evaluation

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Region 9

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Executive Summary

This report describes the document review, data evaluation, and analysis requested by the U.S. Environmental Protection Agency regarding groundwater contamination in the North Hollywood Operable Unit (NHOU) of the San Fernando Valley Superfund Site (Area 1) in Southern California. Groundwater in the central part of the NHOU is contaminated with dissolved chromium and the volatile organic compounds (VOC) trichloroethylene (TCE) and tetrachloroethylene. This investigation of the NHOU focuses on the historical and recent distribution of chromium and six emergent chemicals dissolved in groundwater, the geochemical conditions present in the aquifer, and the potential future movement of these contaminants in the local groundwater system. This analysis relies chiefly on data reported in the San Fernando Valley (SFV) groundwater database maintained by CH2M HILL for EPA. The data were obtained from several sources, including EPA, Honeywell, Lockheed-Martin, the Los Angeles Department of Water and Power (LADWP), and the Los Angeles Regional Water Quality Control Board (LARWQCB).

The primary focus of this investigation is the evaluation of historical and recent detections of dissolved chromium and emergent chemicals in groundwater samples from the NHOU. Historical data refers to samples collected prior to January 2000. Recent data refers to the data collected between January 2000 and December 2004. Additional groundwater data from new wells installed at the Honeywell site (formerly referred to as AlliedSignal) have been evaluated as they have become available. The most recent data for these wells are from May 2005.

Hydrogeologic conditions in the valley-fill deposits of the eastern San Fernando Valley vary with depth, affecting contaminant transport characteristics. The aquifer units have been subdivided by previous investigators using different classification schemes. Since 1996, EPA and CH2M HILL have been defining aquifer zones in the NHOU by depth regions, which are defined by depth intervals below ground surface (bgs). Table ES-1 lists the depth regions and their approximate depths bgs.

TABLE ES-1
Depth Regions in the NHOU
North Hollywood Operable Unit, Chromium Evaluation

Depth Region	Approximate Depth Interval (feet bgs)
1	200 to 280
2	280 to 420
3	420 to 700
4	Greater than 700

Groundwater levels measured at most NHOU monitoring wells have declined approximately 20 to 50 feet since the mid-1990s. Available data suggest that fluctuations of groundwater depths in the NHOU between 200 and 260 feet bgs are routine over decade-scale time periods. In the eastern San Fernando basin, groundwater flow directions generally range

from south to east. Near the NHOU, groundwater flow is primarily influenced by the active production wellfields that surround the NHOU wellfield to the northwest, west, and south. There are also localized effects around individual active wells, including NHOU extraction wells. Groundwater flow velocities in NHOU were estimated during the remedial investigation (RI) to range from approximately 290 to 1,000 feet per year (James M. Montgomery, Inc., 1992). Estimated velocities are generally highest in the area of the NHOU extraction system. Recent measurements of vertical hydraulic gradients at clustered RI wells in NHOU suggest near-neutral to substantial downward vertical gradients from Depth Region 1 to Depth Region 2.

Hexavalent chromium (Cr(VI)), is the dominant chromium species dissolved in groundwater in most of the study area, with concentrations generally similar to total chromium concentrations. Reduction/oxidation (redox) conditions in the study area appear to favor the stability of the more mobile Cr(VI) over the relatively immobile, reduced (trivalent) form of chromium (Cr(III)). Relatively small vertical hydraulic gradients and the presence of lower-permeability sediments in some locations may slow the downward migration of contaminated groundwater.

The emerging contaminants identified in the NHOU are trichloropropane (TCP), 1,4-dioxane, methyl tert butyl ether (MTBE), n-nitrosodimethylamine (NDMA), perchlorate, and thallium. Available data for these contaminants of potential concern were reviewed as part of this investigation.

The applicable standard for total chromium concentrations in groundwater is the State of California maximum contaminant level (MCL). The State of California MCL is the applicable standard for thallium. The State of California drinking water notification levels are the groundwater criteria used for the five emerging contaminants for which no MCL has been established. Table ES-2 lists these water quality standards and criteria.

TABLE ES-2

Groundwater Standards for Contaminants of Concern

North Hollywood Operable Unit Chromium Evaluation

Contaminant of Concern	Groundwater Standard (µg/L)	Type of Standard
Total Chromium	50	State of California MCL
1,2,3-TCP	0.005	State of California drinking water notification level
1,4-Dioxane	3	State of California drinking water notification level
MTBE	13, 5	State of California primary and secondary MCL
NDMA	0.01	State of California drinking water notification level
Perchlorate	6	State of California drinking water notification level
Thallium	2	Federal and State of California MCL

Note:

µg/L = micrograms per liter

The current State of California MCL for total chromium is 50 micrograms ($\mu\text{g/L}$). Historical and recent concentrations of total chromium and hexavalent chromium reported in the database for groundwater samples obtained within the NHOH have only exceeded the MCL on and downgradient of the Honeywell site.

Current and historical data regarding the extents of the six emerging contaminants and trends in their concentrations are very limited. However, the available data suggest that most of these emerging contaminants are not widespread in the NHOH.

A groundwater extraction and treatment system designed to treat VOC contamination within the NHOH began operation in December 1989, with a design capacity and EPA performance goal of 2,000 gallons per minute (gpm). Between 1989 and 2004, the average combined pumping rate for the eight wells of the extraction system was 810 gpm. The reasons for the limited extraction rates include a decline in the regional water table; detection of contaminants (primarily chromium and rarely uranium that is thought to be naturally occurring) that the treatment system was not designed to treat, and occasional delays in maintenance. In addition, extraction well NHE-1 has not been operating since 1989 because the well screen is too shallow and the column of water above the pump is insufficient to sustain active extraction.

The highest recent (2003 to 2004) concentrations of chromium in groundwater have been detected in samples from monitoring wells at the Honeywell site, which is approximately 0.5 mile north of several NHOH extraction wells. Extraction well NHE-2 has been shut down by LADWP for extended periods because chromium concentrations exceeded $20 \mu\text{g/L}$, a voluntary limit established by LADWP.

Contaminant Distribution

Chromium

Chromium commonly occurs in two valence states in groundwater, the relatively immobile trivalent form, and the highly mobile hexavalent form. The hexavalent form appears to be dominant in most NHOH groundwater, due to the oxidizing conditions present at the site. Relatively few data are available for chromium prior to 1998, especially for hexavalent chromium.

The highest concentrations of chromium (as high as $11,000 \mu\text{g/L}$ from well GW-15) in Depth Region 1 occur in samples collected from the Honeywell site monitoring wells. Concentrations of chromium ranging from 5 to $100 \mu\text{g/L}$ have been detected at downgradient NHOH extraction well NHE-2, and concentrations from 3.5 to $14.1 \mu\text{g/L}$ have been detected at NHE-3, -4, -5, and -6. Chromium concentrations are approximately $2 \mu\text{g/L}$ or less at most other NHOH monitoring and production wells.

The May 2005 chromium results reported by Honeywell indicate that chromium is present in several of the Honeywell site monitoring wells at concentrations as high as $11,000 \mu\text{g/L}$ (onsite monitoring well GW-15). An offsite monitoring well, GW-12A, contained Cr(VI) at a concentration of $270 \mu\text{g/L}$ at 319 feet bgs (Depth Region 2). This result suggests horizontal and vertical (downward) offsite transport of dissolved chromium from the Honeywell site. However, these wells contain Barcad sampling devices, which commonly require several

sampling events before analytical results can be considered fully representative of aquifer conditions (Montgomery Watson Harza Americas, Inc. [MWH], 2005)

There is uncertainty regarding the exact concentrations reported for the Honeywell Offsite Investigation Area (OIA). Two of the wells, GW-11 and GW-16, were drilled using mud rotary in response to persistent, heaving sand below the water table. Wells GW-12A and GW-17 were drilled without mud rotary. Grab samples collected from wells GW-11 and GW-16 during well construction yielded Cr(VI) concentrations approximately 2 orders of magnitude greater than the Barcad samples collected subsequently (e.g., 170 µg/L versus 1.7 µg/L in GW-11). Wells GW-12A and GW-17 do not show this discrepancy. In fact, the Barcad sample collected from GW12A is 64 µg/L, and the grab sample was below the detection limit. These results suggest the possibility that mud remaining in the formation that surrounds wells GW-11 and GW-16 is causing reducing conditions that lead to non-representative sampling results. However, despite the uncertainty in exact concentrations, the overall results clearly suggest that elevated Cr(VI) concentrations are present in the aquifer in the vicinity of several of the offsite monitoring wells.

Emerging Contaminants

The emerging contaminants identified in the NHOU are TCP, 1,4-dioxane, MTBE, NDMA, perchlorate, and thallium. Available data for these contaminants of potential concern were reviewed as part of this investigation. Sampling for emergent contaminants has not generally been performed either historically or recently within NHOU; however, all new Honeywell monitoring wells are currently analyzed for these contaminants. The absence of data from monitoring wells at other facilities within the NHOU does not necessarily indicate that the contaminants are not present, but instead reflects the fact that these particular analyses were not performed at other facilities.

The State of California established a notification level of 0.005 µg/L (equivalent to the current detection limit) for 1,2,3-TCP in 1999. The highest concentrations (ranging from 0.02 to 730 µg/L) were detected at Lockheed monitoring wells 3831Q and LC1-CW05 and at NHOU RI monitoring wells NH-C02-325 and NH-C02-520, located south of Burbank Airport along the boundary between NHOU and the Burbank OU. Lower concentrations (0.005 to 0.13 µg/L) have been detected at the Honeywell site, but TCP has not been detected in samples from the most recent groundwater sampling event (May 2005). However, for many of the samples the analytical detection limit was 1 µg/L, which is too high for meaningful comparison to the 0.005 µg/L state notification level. In response to recent detection of 1,2,3-TCP in LADWP well NHE-5, EPA has directed Honeywell to use an analytical method in the future that will detect 1,2,3-TCP at the state notification level.

Few samples of groundwater from wells in the NHOU have been analyzed for 1,4-dioxane. Most detections to date have occurred at the Honeywell site monitoring wells at concentrations ranging from 1 to 32 µg/L. In May 2005, 6 of the 24 Honeywell wells sampled for 1,4-dioxane exceeded the state notification level of 3 µg/L, with the maximum concentration being 16 µg/L.

Data for MTBE are available for many wells in the San Fernando Valley database; however, only three trace detections of less than 1 µg/L have been reported. MTBE was not detected

in the most recent analyses for the presence of MTBE (November 2004) in samples from monitoring wells at the Honeywell site.

Nearly all of the samples that have been analyzed for NDMA from the NHOU have come from Honeywell site monitoring wells. All NDMA detections in the NHOU have occurred at the Honeywell site at concentrations ranging from 0.0022 to 1.06 µg/L (state notification level is 0.01 µg/L). However, because of the limited sampling and analysis for NDMA outside the Honeywell site, it should not be assumed that the Honeywell site is the sole source for NDMA or the only location where it is present.

Groundwater samples from most RI monitoring wells in the NHOU and the monitoring wells at the Honeywell site have been analyzed for perchlorate. All four samples that contained perchlorate in concentrations greater than the California drinking water notification level (6 µg/L) have come from the Honeywell site (concentrations ranging from 8.9 to 19 µg/L).

Historical and recent groundwater samples from most RI monitoring wells in the NHOU and from the Honeywell site monitoring wells have also been analyzed for thallium. Dissolved thallium has been detected in RI monitoring well clusters NH-C01 through NH-C03 at concentrations exceeding the MCL of 2 µg/L (ranging from 3.7 to 6.8 µg/L). Thallium was not detected in samples from the May 2005 sampling event at the Honeywell site.

Anticipated Future Trends

Chromium

Despite geochemical indications that hexavalent chromium should be mobile in groundwater in the NHOU, the lateral and vertical extents of hexavalent chromium contamination in the area appear relatively limited. Whether this lack of mobility is a function of site hydraulics, geochemistry, or some other site feature is not fully understood. The timing of possible chromium releases to groundwater at most of the facilities under investigation by EPA and LARWQCB is largely unknown, although they probably began with the buildup of the aerospace industry in the valley after World War II. Moreover, the historical hexavalent or total chromium concentration data are limited to three or fewer sampling events at most wells, or are limited spatially to dense clusters of monitoring wells near the Honeywell facilities under investigation by LARWQCB. These monitoring history limitations significantly hinder efforts to delineate the distribution of hexavalent and total chromium concentrations and estimate future impacts to groundwater extraction and production wells.

Currently, the hydrogeology of the NHOU and the potential influence of groundwater pumping on groundwater flow directions and velocities are under further investigation by EPA. In addition, the spatial and temporal coverage of chromium concentration data are limited. However, given the estimated groundwater velocities between the chromium source area at the Honeywell site and the downgradient NHOU extraction wells, it is likely that the concentrations presently observed in the NHOU extraction wellfield are in quasi-equilibrium with the current conditions in the source area. Therefore, it is likely that future chromium concentrations in the NHOU extraction wells will remain similar to those

observed today unless the dynamics within the source area change due to rising groundwater levels, changing groundwater flow directions, or other hydrologic influences.

Observed VOC and chromium concentrations within monitoring wells at the Honeywell source area were compared with those observed in NHOU extraction well NHE-2 in an attempt to estimate dilution factors for both TCE and chromium. It is expected that the contaminant concentrations in well NHE-2 will be lower than those observed in monitoring wells within the source area because of dispersion during transport and dilution at the production well. However if the dilution factors are the same for TCE and chromium, it can be assumed that both contaminants are undergoing the same attenuation processes and that no additional geochemical factors are selectively affecting chromium. The results of this analysis suggest that, on average, TCE is attenuated by a factor of 5 between the Honeywell site and extraction well NHE-2 while chromium is attenuated by a factor of approximately 25. The method and assumptions used to calculate these attenuation factors for TCE and chromium are discussed in Section 4.0. While these results may suggest additional geochemical attenuation of chromium over TCE during transport, it should be noted that the data sets are highly variable, and these results are average trends.

EPA is currently performing a focused feasibility study (FFS) for the NHOU; the groundwater modeling performed to support the FFS will help further define groundwater flow directions and velocities in the area. The 2005 contaminant data should facilitate improved predictions of future contaminant concentration trends.

In July 2004, Honeywell submitted a Soil and Interim Groundwater Remediation Action Plan for cleanup of the onsite chromium contamination. The plan was approved by LARWQCB in April 2005, and site-specific chromium remediation is in the planning stage.

Emerging Contaminants

Current and historical data regarding the extents of emerging contaminants and trends in their concentrations are very limited. However, the available data indicate that most of the emerging contaminants are not widespread in the NHOU. In general, concentrations of the emerging contaminants in the NHOU are relatively low compared to the regulatory thresholds (MCLs or drinking water notification levels) where data are available, although concentrations are greater than regulatory thresholds at some locations. Most of these contaminants do not naturally attenuate to a great extent in groundwater and could migrate to extraction or production wells in the future, although not necessarily at concentrations that would be detectable or require treatment.

Conclusions

The conclusions resulting from the review of available data for the NHOU, focusing on the area and contaminants likely to affect future operation of the NHOU extraction system and nearby LADWP production wellfields are presented below.

Chromium Distribution. Conclusions regarding chromium distribution include the following:

- Redox conditions in the NHOU appear to favor the stability of the more mobile Cr(VI) rather than the relatively immobile reduced form, (CrIII).

- Chromium concentrations in samples collected in May 2005 from the Honeywell site monitoring wells suggest that there is a significant chromium source mass in groundwater beneath the Honeywell site.
- The estimated travel time for groundwater contamination between the chromium source area at the Honeywell site and downgradient NHOU extraction wells is on the order of 1 to several years. This suggests that the dissolved chromium concentrations detected in NHOU extraction wells reflect current conditions within the source area and are not expected to change significantly in the future unless concentrations in the source area change. This could occur in response to many factors, including increasing groundwater levels that might mobilize the chromium mass currently present in the vadose zone or remedial actions conducted at the Honeywell site.
- The average attenuation factor, or dilution factor, for dissolved chromium traveling between the Honeywell site and downgradient NHOU extraction well NHE-2 is approximately 25, while the dilution factor for TCE is approximately 5. This could suggest the existence of an additional geochemical attenuation process acting on chromium that does not affect TCE during transport, but it should be noted that the data sets used in the analysis are highly variable, and the differences between the calculated dilution factors also could represent sampling variability.

Emerging Contaminants. Emerging contaminants appear limited in vertical and lateral extent within the NHOU; however, they are mobile and persistent. Concentrations of some emerging contaminants have exceeded California Department of Health Services notification levels at a limited number of monitoring locations. However, concentrations of the emerging contaminants are generally below the regulatory thresholds.

NHOU Extraction System. Future increases in groundwater levels could mobilize the chromium mass currently residing in the vadose zone, causing concentrations of chromium at NHOU extraction wells to increase and possibly reach levels that would require modifications to the existing treatment process.

Groundwater Monitoring. Groundwater level measurement data are needed to provide additional groundwater flow and hydraulic gradient information.

NHOU Treatment Plant. At this time, the NHOU treatment plant is operating substantially below its design capacity for influent flow rate and VOC mass removal. The plant's VOC treatment capacity should be adequate to handle the design influent flow rate of 2,000 gpm.

Recommendations

Recommendations for improvements to the NHOU extraction system and future groundwater monitoring are as follows:

NHOU Treatment System. Evaluate options to increase the performance of the NHOU treatment system.

Groundwater Monitoring. Recommendations regarding groundwater monitoring include the following:

- Continue regular monitoring for chromium, emerging contaminants, and inorganic geochemical indicator parameters at the Honeywell site monitoring wells. The November 2004 and May 2005 data are valuable additions to the available chromium data. Determining the concentrations, lateral extents, and vertical extents of contaminants in this area, where the highest chromium concentrations in the NHOU have been detected, is key to forecasting future groundwater quality impacts. In addition, in the August 2005 cooperative agreement with DWP, EPA requested monitoring of chromium at all NHOU extraction wells and monitoring of 1,2,3-TCP at NHOU extraction well NHE-5, where TCP was previously detected above the notification level.
- Collect data from other possible sources of groundwater contamination in the NHOU. Groundwater quality data from these sources should be incorporated into the NHOU evaluation as they are made available. Coordination of site-specific groundwater investigations with LARWQCB will be necessary to identify the contaminant source areas.
- Install additional monitoring wells near the NHOU extraction system and surrounding production wellfields, or convert existing production wells for use as monitoring wells. The current network of RI monitoring wells is too sparse in important locations and has not been substantially modified since 1989. Key locations for additional paired monitoring wells (Depth Regions 1 and 2) are shown on Figure 13 (figure is located at the end of this report).
- Continue monthly monitoring for total chromium and Cr(VI) at the NHOU extraction wells. High concentrations of total chromium and Cr(VI) are present in groundwater at the Honeywell site, located a few thousand feet north of several NHOU extraction wells. Chromium concentrations in groundwater at these extraction wells could rapidly change in response to future groundwater level changes. Continued frequent monitoring is warranted.
- Collect contemporaneous groundwater level data sets during spring and fall at additional, essential well locations to discern seasonal fluctuations in groundwater flow directions and gradients. Contemporaneous water level data sets are necessary to improve understanding of the hydraulic conditions and groundwater flow directions across the NHOU and in the aquifer system.
- Modify the monitoring schedule for existing and proposed monitoring wells, facility monitoring wells, and production wells as necessary to provide data at key locations and times. This should be a coordinated monitoring plan that includes triggers for increasing or decreasing sampling frequency to provide crucial data about groundwater conditions throughout the NHOU.
- Coordinate with lead agencies to ensure that efforts to clean up source areas are consistent with EPA's approach to addressing high concentrations of chromium. Remediation of source zones could substantially decrease both the contaminant concentrations at the NHOU extraction wells and the length of time the extraction system must be operated. Consistency in approach should maximize the effectiveness of remedial efforts.

Contents

	Page
Section	
Executive Summary	ES-1
Acronyms and Abbreviations.....	v
1.0 Introduction	1-1
1.1 Background.....	1-3
1.2 Investigative Methods and Approach	1-4
1.3 Previous Investigations.....	1-5
1.4 Summary of Well Data Evaluated	1-6
1.5 Summary of Hydrogeologic Conditions	1-6
1.6 Recent Honeywell Monitoring Well Data	1-9
2.0 Geochemical Conditions Affecting Chromium Transport.....	2-1
2.1 Chromium Geochemistry	2-1
2.2 General Chemistry	2-2
2.3 Redox Conditions	2-2
3.0 Nature and Extent of Contamination.....	3-1
3.1 Chromium.....	3-1
3.1.1 Historical and Recent Distribution of Chromium.....	3-2
3.1.2 More Recent Honeywell Facility Monitoring Well Chromium Data	3-4
3.2 Emerging Contaminants.....	3-7
3.2.1 1,2,3-Trichloropropane.....	3-10
3.2.2 1,4-Dioxane	3-10
3.2.3 Methyl Tert Butyl Ether	3-10
3.2.4 n-Nitrosodimethylamine	3-11
3.2.5 Perchlorate	3-11
3.2.6 Thallium.....	3-12
4.0 Anticipated Future Trends.....	4-1
4.1 Chromium.....	4-1
4.2 Emerging Contaminants.....	4-3
5.0 Conclusions and Recommendations.....	5-1
5.1 Conclusions	5-1
5.2 Recommendations	5-2
6.0 Works Cited	6-1

Appendix A

Chromium Time Series Plots For North Hollywood Operable Unit and Other Selected Wells

Contents, Continued

	Page
Tables	
1-1	Groundwater Standards for Contaminants of Concern 1-2
1-2	Well Construction Details for the Honeywell Site..... 1-10
3-1	Chromium Concentrations in Preliminary Samples Collected from Honeywell Offsite Investigation Area Monitoring Wells 3-5
3-2	Total and Hexavalent Chromium Concentrations from Samples Collected at the Honeywell Site during the May 23, to May 25, 2005 Sampling Event 3-8
3-3	Emerging Contaminants Concentrations from Samples Collected at the Honeywell Site during May 2005..... 3-9

Figures	
1	Location Map
2	Schematic Hydrogeologic Section
3	Historical Maximum Chromium Concentrations, Depth Region 1
4	Historical Maximum Chromium Concentrations in Depth Regions 2 through 4
5	Recent Maximum Chromium Concentrations in Depth Region 1
6	Recent Maximum Chromium Concentrations in Depth Regions 2 through 4
7	Selected Chromium Time Series, Depth Region 1
8	Selected Chromium Time Series, Depth Region 2
9	Cross Section A-A'
10	Cross Section B-B'
11	May 2005 Total Chromium Concentrations at Honeywell Site
12	May 2005 Hexavalent Chromium Concentrations at Honeywell Site
13	Recommended Additional Monitoring Well Locations

Acronyms and Abbreviations

µg/L	micrograms per liter
bgs	below ground surface
Cr(III)	trivalent chromium
Cr(OH) ₃	chromium hydroxide
Cr(VI)	hexavalent chromium
DHS	California Department of Health Services
Eh	redox potential
EPA	U.S. Environmental Protection Agency
gpm	gallons per minute
JMM	James M. Montgomery, Inc.
LADWP	Los Angeles Department of Water and Power
LARWQCB	Los Angeles Regional Water Quality Control Board
MCL	maximum contaminant level
mg/L	milligrams per liter
MTBE	methyl tert butyl ether
mV	millivolt
MWH	Montgomery Watson Harza Americas, Inc.
NA	not analyzed
ND	not detected
NDMA	n-nitrosodimethylamine
NHOU	North Hollywood Operable Unit
OIA	Offsite Investigation Area
OU	operable unit
PCE	tetrachloroethylene
PVC	polyvinyl chloride
redox	reduction oxidation
RI	remedial investigation

SFV	San Fernando Valley
TCE	trichloroethylene
TCP	trichloropropane
VOC	volatile organic compound

Introduction

This report describes the document review, data evaluation, and analysis requested by the U.S. Environmental Protection Agency (EPA) regarding groundwater contamination in the North Hollywood Operable Unit (NHOU) of the San Fernando Valley Superfund Site (Area 1) in Southern California. The location of the NHOU is shown on Figure 1 (all figures are located at the end of this report). Groundwater in the central part of NHOU is contaminated, primarily with dissolved chromium and the volatile organic compounds (VOC), trichloroethylene (TCE) and tetrachloroethylene (PCE). In contrast to the most recent 5-year review of NHOU performance, this report incorporates data through 2005. This investigation was performed under EPA Work Assignment No. 187-TATA-09N1 (Contract 68-W-98-225).

This report focuses on the historical and recent distribution of chromium and emergent chemicals dissolved in groundwater, the geochemical conditions present in the aquifer, and the potential future movement of these contaminants in the local groundwater system. The report also considers potential impacts of known groundwater contamination from chromium or certain emerging contaminants on NHOU extraction wells and treatment system. This analysis relies chiefly on data reported in the SFV groundwater database maintained by CH2M HILL for EPA. The data were obtained from several sources, including EPA, Honeywell, Lockheed-Martin, the Los Angeles Department of Water and Power (LADWP), and the Los Angeles Regional Water Quality Control Board (LARWQCB).

The primary contaminant of concern evaluated is dissolved chromium. The following emerging contaminants were also evaluated as potential constituents of concern:

- 1,2,3-Trichloropropane (TCP)
- 1,4-Dioxane
- Methyl tert butyl ether (MTBE)
- n-Nitrosodimethylamine (NDMA)
- Perchlorate
- Thallium

Environmental data, monitoring well coverage, source identification, and groundwater information were all taken from existing investigation reports and studies. Groundwater contamination could be present at different concentrations at certain locations or facilities, and the nature and extent of contamination in the SFV groundwater basin overall could fluctuate over time. Therefore, this report should not be used to draw definitive conclusions regarding the overall or long-term severity or extent of groundwater contamination in the broader NHOU area or the SFV groundwater basin.

The current regulatory limit for total chromium in SFV groundwater is the California maximum contaminant level (MCL) of 50 micrograms per liter ($\mu\text{g/L}$). State legislation passed in 2001 required the California Department of Health Services (DHS) to adopt an MCL for hexavalent chromium (Cr(VI)) by January 1, 2004. However, before DHS can adopt an MCL,

the Office of Environmental Health Hazard Assessment must first issue a public health goal for the contaminant. The schedule for issuing a public health goal for Cr(VI) was delayed, pending completion of a study by the National Toxicology Program (part of the U.S. Department of Health and Human Services) on the toxicity of Cr(VI). To date, the public health goal and MCL for hexavalent chromium have not been developed.

The applicable standard for total chromium concentrations in groundwater is the State of California MCL. The State of California drinking water notification levels are the groundwater criteria used in this report for evaluating concentrations of the five emerging contaminants for which no MCL has been established. The State of California MCL is the applicable standard for thallium. Table 1-1 lists these water quality standards and criteria.

TABLE 1-1

Groundwater Standards for Contaminants of Concern
North Hollywood Operable Unit Chromium Evaluation

Contaminant of Concern	Groundwater Standard (µg/L)	Type of Standard
TCE	5	Federal and State of California MCL
PCE	5	Federal and State of California MCL
Total Chromium	50	State of California MCL
TCP	0.005	State of California drinking water notification level
1,4-Dioxane	3	State of California drinking water notification level
MTBE	13, 5	State of California primary and secondary MCL
NDMA	0.01	State of California drinking water notification level
Perchlorate	6	State of California drinking water notification level
Thallium	2	Federal and State of California MCL

In this report, the existing California MCL for total chromium (50 µg/L) is used as the benchmark for assessing total and hexavalent chromium in groundwater in the NHOU. The City of Los Angeles Department of Water and Power (LADWP) operates the extraction and treatment system for the NHOU and has established voluntary limits on acceptable levels of Cr(VI) at varying points of compliance (e.g., individual extraction wells, discharge from the treatment system, and drinking water after blending with other sources). If an MCL for Cr(VI) is adopted that is substantially lower than the 50 µg/L, the conclusions presented herein regarding the impacts of chromium in the NHOU and at the NHOU treatment system will require re-evaluation.

The information in this report will assist EPA in determining the appropriate next steps to address groundwater contamination in the NHOU. An earlier study was conducted to investigate chromium trends in the adjacent Burbank, Glendale North, and Glendale South Operable Units (OU) (CH2M HILL, 2005). Although this evaluation has a broader scope because of the number of contaminants investigated, the status of chromium groundwater contamination in NHOU was evaluated in a similar manner as the earlier study to provide a better understanding of the extent of known chromium groundwater contamination in the

eastern SFV, and whether this chromium contamination might reduce the effectiveness of the NHOU treatment system.

1.1 Background

In 1986, EPA placed four groundwater areas in the eastern SFV on the National Priorities List in response to detections of TCE and PCE in groundwater at concentrations that exceeded the MCL. These areas are as follows:

- Area 1 – North Hollywood, which includes the NHOU and the Burbank OU
- Area 2 – Glendale and Crystal Springs, which includes the Glendale North and Glendale South OUs
- Area 3 – Verdugo
- Area 4 – Pollock Wellfield

The EPA issued an interim Record of Decision (ROD) for the NHOU in September 1987. The decision addressed the VOC-contaminated groundwater plume in the NHOU. The remedy specified in the decision included VOC-plume containment using eight groundwater extraction wells, groundwater treatment using air stripping, and granulated activated carbon treatment of vapor-phase contaminants discharged from the air stripper (CH2M HILL, 2003). Construction of the groundwater treatment system was completed in March 1989, and operation commenced in December 1989 (CH2M HILL, 1998). As part of a basinwide remedial investigation (RI) completed in 1992, 87 groundwater monitoring wells were installed throughout the eastern SFV.

The NHOU extraction wellfield design capacity is 2,000 gpm. The performance goal set by EPA for the NHOU treatment plant was to operate at the same flow rate, 2,000 gpm (CH2M HILL, 2003a). Since its completion in 1989, the groundwater treatment plant has not operated at the design capacity. The average combined flowrate from the extraction wells in the October 2003 through September 2004 water year was 712 gpm. Reasons cited for the limited pumping are as follows:

- The regional groundwater table has declined.
- Extraction well NHE-1 has not been operating since 1989 because the well screen is too shallow and the column of water above the pump is insufficient.
- New contaminants of concern, such as chromium, that were not identified in the ROD and are not removed by the existing treatment system have led to periodic, voluntary shutdowns of extraction wells (e.g., extraction well NHE-2 has been shut down periodically when chromium levels have reached the LADWP voluntary limit in the extracted groundwater). The voluntary shutdowns occurred until 2004, when the City of Los Angeles changed its extraction well voluntary shutdown practice.
- Delays have occurred in the maintenance of the NHOU extraction wells and treatment facility.

- In addition to the NHOU extraction wellfield, several major production wellfields exist in and near the NHOU. These include the North Hollywood West, Rinaldi-Toluca, and Whitnall production wellfields, and they are referred to as production wellfields throughout this report. Similarly, the Honeywell site monitoring wells are distinct, and are referred to as Honeywell or facility monitoring wells.

1.2 Investigative Methods and Approach

The primary focus of this report is the evaluation of historical and recent dissolved chromium and emergent chemical concentrations in groundwater samples from the NHOU. Historical data refers to samples collected prior to January 2000; recent data refers to data collected between January 2000 and December 2004. Additional groundwater data from new wells installed at the Honeywell site (formerly AlliedSignal) have been evaluated as they have become available. The most recent data for these wells are from May 2005.

As required under the work assignment, the primary data sources for this evaluation include the following documents, provided by EPA or on file at CH2M HILL:

- Environmental Protection Agency. 1987. *Record of Decision for Area 1 (NHOU) of the San Fernando Valley Superfund Site*.
- James M. Montgomery, Inc. 1992. *Remedial Investigation of Groundwater Contamination in the San Fernando Valley* (James M. Montgomery, Inc. [JMM], 1992)
- Los Angeles Department of Water and Power. 1988. *Operation and Maintenance Manual for the North Hollywood-Burbank Aeration Emissions Control Facility*.
- Available monthly and quarterly reports for NHOU operations, prepared by LADWP from June 1998 through the present
- CH2M HILL. 1998. *Five-year Review Report: North Hollywood Operable Unit Facility, San Fernando Valley Superfund Site – Area 1, Los Angeles County, California*.
- CH2M HILL. 2003. *Third Five-year Review Report for North Hollywood Operable Unit, San Fernando Valley (Area 1) Superfund Site, Los Angeles County, California*.
- Los Angeles Department of Water and Power. 2002. *Draft Evaluation of the North Hollywood Operable Unit and Options to Enhance Its Effectiveness*.
- Los Angeles Department of Water and Power. 2003. *Final Evaluation of the North Hollywood Operable Unit and Options to Enhance Its Effectiveness*.
- Montgomery Watson Harza Americas, Inc. 2005. *Groundwater Monitoring Report, Second Quarter 2005, Honeywell North Hollywood Site*.

In addition to these documents, several other reports were reviewed and data sources applied to the present investigation, including, but not limited to, the following:

- The San Fernando Valley groundwater database maintained by CH2M HILL for EPA (includes groundwater quality, level, and withdrawal data reported to EPA by LARWQCB, municipalities, and other facilities).

- CH2M HILL. 1996. *Evaluation of the Past and Potential Performance of the North Hollywood Operable Unit Facility, San Fernando Valley Superfund Site, Los Angeles County, California.*
- Upper Los Angeles River Area Watermaster. 2003. *Watermaster Special Report Concerning the History and Occurrence of Hexavalent Chromium Contamination in the San Fernando Basin and Watermaster Conclusions and Recommendations.*
- Upper Los Angeles River Area Watermaster. 2004. *Groundwater Pumping and Spreading Plan: 2003-2008 Water Years.*
- CH2M HILL annual monitoring reports for the RI monitoring wells.
- CH2M HILL. 2005. *Burbank and Glendale Operable Units, Focused Chromium Trend Study.*

In addition, information exchanged at meetings and conference calls with LADWP and the Upper Los Angeles River Area Watermaster while reviewing their data and modeling results facilitated this evaluation. Data obtained from these sources were used to update and refine the conceptual understanding of groundwater contamination in the NHOU. The data were also used to prepare new maps that illustrate plume development over time, which are used to evaluate present and potential future impacts to both upper and lower aquifer units in the area.

1.3 Previous Investigations

In 1979 and 1980, sampling of groundwater production wells in the SFV indicated the presence of chlorinated VOCs, most notably TCE and PCE, exceeding state and federal standards (JMM, 1992). In August 1985, samples from 27 of LADWP's 38 most active wells in the NHOU contained TCE concentrations greater than the MCL. LADWP shut down several contaminated wells in the North Hollywood East wellfield (CH2M HILL, 1998). In 1984, LADWP began planning for a groundwater extraction and remediation system to prevent further migration of contaminated groundwater (LADWP, 2003). Depth-specific sampling conducted at that time suggested that most of the contaminant mass threatening LADWP supply wells occurred in the upper zone aquifer. In 1985, the EPA placed the area in a fast-track evaluation so that remedial action could be started before the RI and feasibility study were completed. In 1989, EPA issued an interim ROD, which required extraction and treatment of the groundwater.

In 1989, the groundwater extraction and treatment system, including eight extraction wells (NHE-1 through -8) and an air-stripping treatment plant were constructed to contain contaminated groundwater and treat it to levels acceptable for municipal use. The combined design pumping rate from the eight extraction wells was 2,000 gpm, which was expected to hydraulically contain the known TCE plume (LADWP, 2003). However, the design extraction rate was never achieved, and low groundwater levels at extraction well NHE-1 have always prevented it from being operated. Groundwater levels in the NHOU were at or near historical highs in 1984, when LADWP designed the extraction system. Those levels declined 50 feet or more by 1989, when construction of the extraction wells was complete and the system began operation. Since 1989, the long-term average pumping rate from the extraction system has been 810 gpm (operational uptime of 80 percent), actual pumping rates have varied substantially, and long periods of system downtime (weeks to months)

have occurred frequently. In addition, extraction well NHE-1 has not been operating since 1989 because the well screen is too shallow, and the column of water above the pump is insufficient.

During a 2003 evaluation of the effectiveness of the NHOU extraction system, LADWP concluded that the system should effectively be capturing most of the TCE and PCE plumes in the upper aquifer zone. LADWP's analysis was based on results of LADWP's groundwater flow model for the SFV, and assumed that the average pumping rate of the extraction system at the time, 1,570 gpm, would be maintained continuously (LADWP, 2003). However, total chromium in groundwater from extraction well NHE-2 subsequently was measured at concentrations exceeding 20 µg/L, causing LADWP to voluntarily shut down this well for extended periods.

1.4 Summary of Well Data Evaluated

The well data used for this chromium evaluation are recorded in the SFV groundwater database, which is maintained by CH2M HILL for EPA. The data were obtained from several sources, including EPA, Honeywell, Lockheed-Martin, LADWP, and LARWQCB. Of the 227 wells in the NHOU, 121 have been sampled at least once for dissolved chromium or emergent chemicals. A summary of these wells is as follows:

- 45 LADWP wells
- 22 EPA RI monitoring wells
- 33 Honeywell monitoring wells
- 7 Lockheed monitoring wells
- 14 Landfill monitoring wells (Hewitt, Newberry, Penrose, Sheldon-Arleta, and Tuxford Landfills, and Strathern Pit)

Many of these wells have been sampled only once or have only been sampled sporadically; therefore, the data presented might not be fully representative of actual conditions. The best areal coverage and most consistent data have been obtained from the wells at the Honeywell site. Of the 121 wells evaluated, only the Honeywell wells and two down-gradient EPA wells have had concentrations of dissolved chromium that exceed the state MCL of 50 µg/L. The EPA, LARWQCB, and the Department of Toxic Substance Control are currently working to identify other potential sources of chromium.

1.5 Summary of Hydrogeologic Conditions

Groundwater in the eastern SFV occurs primarily in alluvial valley-fill deposits of Quaternary age, eroded from the adjacent San Gabriel and Verdugo Mountains. The valley fill is estimated to be at least 1,200 feet thick in places, and is bounded to the east and at depth by low-permeability granitic and metamorphic bedrock. The valley-fill deposits of the eastern SFV are relatively permeable, and have been subdivided by previous investigators

using different classification schemes. For the RI, the basin-fill alluvium was subdivided into the following four lithologic/aquifer zones (JMM, 1992):

- **Upper Zone.** The upper zone consists of layers and lenses of silt, sand, and gravel from ground surface to approximately 250 feet below ground surface (bgs). According to aquifer tests conducted during the San Fernando Valley RI in the North Hollywood and Crystal Springs Study Areas, hydraulic conductivities in the upper zone range from approximately 30 to 360 feet per day. The water table commonly occurs in this zone. In late 2004, only the lower 20 to 50 feet of this zone were saturated within much of the NHOU. Groundwater levels have increased by varying amounts in the SFV following the heavy winter rains in late 2004 and early 2005. Available data from monitoring wells in the vicinity of the NHOU extraction system indicate that groundwater levels have typically risen about 15 feet between mid 2004 and mid 2005.
- **Middle Zone.** The middle zone is approximately 50 feet thick and, in some areas, contains increased proportions of fine-grained sand and silt compared to the other zones. Because of its fine-grained nature and anticipated poor yield characteristics, few production wells have been completed in this zone. In some areas of the SFV, the middle zone acts as a confining layer. However, in the north and west parts of the NHOU, the middle aquifer zone appears to consist of more permeable sediments that might allow significant vertical groundwater flow.
- **Lower Zone.** The lower zone consists of interbedded sand, silt, and gravel, with cobbles in the upper portion. The thickness of this zone is estimated to be 200 to 250 feet, and hydraulic conductivity ranges from 130 to 900 feet per day. Many of LADWP's water supply wells in the NHOU are screened in this highly productive zone.
- **Deep Zone.** Where encountered during drilling, the deep zone consists mainly of fine-grained, relatively low-permeability sediments, including silt and clay. Few wells have penetrated this zone; therefore, thickness and hydraulic characteristics of this zone are poorly understood.

Since 1996, EPA and CH2M HILL have been defining aquifer zones in the NHOU by depth regions, which are defined somewhat differently from the four zones described in the RI (CH2M HILL, 1996 and 2003b). These four depth regions are all below the water table and correspond to common screened intervals (typically placed in more permeable strata) for monitoring and production wells in the NHOU. Following are descriptions of each of the four depth regions (CH2M HILL, 1996):

- **Depth Region 1.** This depth interval occurs from 200 to 280 feet bgs, with a typical thickness of 75 feet. Depth Region 1 generally corresponds with the upper zone and the upper half of the middle zone (as defined in the RI); it includes the screened intervals for most shallow monitoring wells and some older production wells.
- **Depth Region 2.** This depth interval ranges from about 280 to 420 feet bgs, with a typical thickness of 140 feet. Depth Region 2 generally corresponds with the lower half of the middle zone and the upper part of the lower zone; it includes highly permeable deposits that are penetrated by most production wells in the NHOU.

- **Depth Region 3.** This depth interval occurs from about 420 to 700 feet bgs, with a typical thickness of 280 feet. Depth Region 3 generally corresponds with the lower part of the lower zone and the upper part of the deep zone; it can be very permeable and includes the screened intervals for many of the newer production wells in the NHOU.
- **Depth Region 4.** This depth interval includes all of the basin-fill alluvial deposits deeper than 660 to 700 feet bgs, with a typical thickness ranging from 100 feet to more than 500 feet; it generally corresponds with the lower part of the deep zone, which few wells have penetrated.

A conceptual cross section illustrating both systems for defining vertical zones in the SFV is shown on Figure 2. Depth to groundwater measured recently (2003 to 2004) at monitoring wells in the vicinity of the NHOU extraction system ranged from approximately 200 to 300 feet bgs. The land surface in the NHOU generally slopes to the south-southeast at a steeper gradient than the water table, which also slopes to the south-southeast, with some local variability caused by pumping from the various wellfields in the area. Therefore, both the depth to the water table and the elevation of the water table decrease to the south-southeast.

In 2003 and 2004, the depth to groundwater in non-pumping wells near the NHOU extraction wellfield was approximately 250 to 270 feet bgs. North of the NHOU extraction wells, the depth to groundwater is typically greater, ranging from 270 to 280 feet bgs at the Honeywell site. The water table, or potentiometric surface, typically occurs within Depth Region 1 (the upper aquifer zone) of the regional aquifer, as shown on Figure 2. Few recent groundwater level measurements are available in the SFV database for the NHOU extraction wells or other pumping wells in the immediate vicinity. Pumping groundwater levels at the NHOU extraction wells are reportedly approaching the depths of the pump intakes, near the bottom of the screened intervals, in the range of approximately 260 to 290 feet bgs.

Groundwater levels measured at most NHOU monitoring wells have declined approximately 20 to 50 feet since the mid-1990s, which corresponds to increases in groundwater production and declines in recharge in the SFV. Available historical data for production and monitoring wells in the vicinity of the NHOU extraction system indicate that the water table has fluctuated from 200 feet bgs or less to 260 feet bgs at least three times in the past 40 years.

Horizontal hydraulic gradients in the eastern SFV are generally south and east toward the Los Angeles River Narrows, where essentially all groundwater and surface water outflow from the SFV occurs (see Figure 1). In the NHOU, horizontal hydraulic gradients range from south to northeast, with the active production wellfields having localized effects on groundwater flow. The groundwater flow direction near the NHOU extraction system can change in response to seasonal and annual variations in pumping rates at the nearby Rinaldi-Toluca wellfield (to the northwest), North Hollywood West wellfield (to the west), and Whitnall wellfield (to the south). Pumping in the Burbank OU (to the east) and more distant wellfields in the NHOU also might affect hydraulic gradients and groundwater flow directions, although to a lesser extent.

Near pumping centers, vertical hydraulic gradients develop from the upper and deep zones toward the lower zone, where most groundwater withdrawals occur. Recent vertical

groundwater level measurements at clustered RI wells in the NHOU indicate near-neutral to substantial downward vertical gradients from Depth Region 1 to Depth Region 2. The downward hydraulic gradients are likely caused by decreased pumping from Depth Region 1 (the upper aquifer zone) as groundwater levels decline, combined with stable or increased pumping from Depth Regions 2 and 3 (the lower aquifer zone).

Groundwater flow velocities in the NHOU were estimated during the RI to range from approximately 290 to 1,000 feet per year, depending on location (JMM, 1992). Estimated groundwater flow velocities are generally highest in the area of the NHOU extraction system, where aquifer hydraulic conductivities are highest.

1.6 Recent Honeywell Monitoring Well Data

As requested by EPA and LARWQCB, Honeywell reinstituted groundwater monitoring for VOCs at the existing onsite groundwater monitoring wells in late 2004. Therefore, recent data are now available for the Honeywell site. Although the Honeywell data are reported here and are a substantial focus of this report, it should not be inferred that there are no other potential sources of contaminants of concern in the NHOU.

Honeywell installed four offsite groundwater monitoring wells in the adjacent offsite investigation area (OIA). These wells have also been sampled recently; therefore, current data for some of the properties between the Honeywell site and the NHOU extraction wells are also available.

In July 2004, Honeywell submitted a Soil and Interim Groundwater Remediation Action Plan for cleanup of the onsite chromium contamination. The plan was approved by the LARWQCB in April 2005, and site-specific chromium remediation is in the planning stage (LARWQCB, 2005).

The most recent groundwater sampling event at the Honeywell site occurred between May 23 and 26, 2005. This was the first time that all of the Honeywell site wells, including OIA wells, had been sampled concurrently. Data from the most recent sampling event have been incorporated into the analyses of trends, predictions of future trends, and recommendations.

Table 1-2 lists the screened intervals for the wells, their installation dates, and other construction details. The wells in OIA, GW-11, GW-12A, GW-16, and GW-17, were installed between December 2004 and April 2005. These four wells include multiple intervals, which are sampled using Barcad (discrete-interval) samplers (MWH, 2005).

TABLE 1-2

Well Construction Details for the Honeywell Site
North Hollywood Operable Unit Chromium Evaluation

Well	Installation Date	Screen Length (feet)	Screen Interval (feet bgs)	Total Depth (feet bgs)	Diameter (inches)	Screen Slot Size (inches)	Screen Type
V13ALSW1	07/12/91	60	245 to 305	305	4	0.030	Schedule 80 PVC
V13ALSW2	07/01/91	60	241 to 301	301	4	0.030	Schedule 80 PVC
V13ALSW3	07/09/91	60	245 to 305	305	4	0.030	Schedule 80 PVC
V13ALSW4	07/03/91	60	245 to 305	305	4	0.030	Schedule 80 PVC
V13ALSW5	06/27/91	60	248 to 308	308	4	0.030	Schedule 80 PVC
V13ALSW6	07/16/91	60	245 to 305	305	4	0.030	Schedule 80 PVC
V13ALSW7	07/01/93	80	230 to 310	310	4	0.030	Stainless steel
V13ALSW8	07/19/93	80	225 to 305	305	4	0.030	Stainless steel
V13ALSW9	07/23/93	80	223 to 303	303	4	0.030	Stainless steel
V13ALS10	07/12/93	80	230 to 310	310	4	0.030	Stainless steel
GW-11	04/06/05	30	270 to 300	450.5	6	0.020	Schedule 80 PVC
		20	310 to 330				
		20	345 to 365				
		20	405 to 425				
		20	430 to 450				
GW-12A	12/14/04	60	270 to 330	360	4	0.020	Schedule 80 PVC
		20	340 to 360				
GW-14A	12/04/03	30	255 to 285	285	4	0.020	Schedule 80 PVC
GW-14B	12/12/03	27	285 to 312	312	6	0.020	Schedule 80 PVC
GW-15	04/15/04	85	245 to 330	335	6	0.020	Stainless steel
GW-16	03/17/05	20	270 to 290	570	6	0.020	Schedule 80 PVC
		20	310 to 330				
		20	340 to 360				
		20	410 to 430				
		20	500 to 520				
GW-17	02/17/05	20	269.5 to 289.5	350	6	0.020	Schedule 80 PVC
		20	309.5 to 329.5				
		10	339.5 to 349.5				

Notes:

Well construction data were adapted from MWH, 2005.

PVC = polyvinyl chloride.

Geochemical Conditions Affecting Chromium Transport

This section summarizes chromium-specific geochemical, general chemical, and reduction oxidation (redox) conditions that could affect chromium mobility in the NHOU. General water chemistry parameters were examined to evaluate geochemical conditions in the NHOU. These parameters include major ions (sodium, calcium, magnesium, chloride, bicarbonate, and sulfate) and general properties (pH, redox potential, and total dissolved solids). Chromium mobility depends on its dominant redox state, so other available redox-sensitive parameters were also used to assess the potential for chromium transport. These parameters included dissolved oxygen, nitrate, ammonia, dissolved manganese, dissolved iron, and sulfide.

2.1 Chromium Geochemistry

Chromium can occur in two valence states in water under normal natural conditions: trivalent, Cr(III), and hexavalent, Cr(VI). Both can exist simultaneously, although typically one state has a much greater concentration than the other. Mobility of Cr(III) is much lower than that of Cr(VI) because Cr(III) forms insoluble precipitates and tends to adsorb strongly to common aquifer solids such as iron oxides and clay minerals. Throughout the pH range found in the study area, Cr(III) is thermodynamically favored to form chromium hydroxide ($\text{Cr}(\text{OH})_3$), an insoluble precipitate that would maintain the dissolved chromium concentration below $0.05 \mu\text{g/L}$ (Richard and Bourg, 1991).

By contrast, Cr(VI) does not form insoluble solids and is weakly adsorbed to subsurface materials. Cr(VI) exists in solution as an oxyanion, either as HCrO_4^- (bichromate) below pH 6.5 or as chromium hydroxide CrO_4^{2-} (CrO_4^{2-} ; chromate) above pH 6.5. The chromate form would be favored in the NHOU. Like other anions, chromate tends to adsorb to aquifer solids more strongly at low pH levels, decreasing in adsorption extent at neutral to high pH levels, as is anticipated to be present in the NHOU.

Reported historical concentrations of chromium in the NHOU are highly variable. This is partly because of differing analytical methods used by the various laboratories and variation in sample collection and preservation during different investigations. Water samples are analyzed for chromium most commonly as total chromium, which represents the sum of Cr(III) and Cr(VI). Samples might not have been filtered before analysis. Many of the historical chromium analytical data reviewed for this study were reported as unfiltered or did not specify whether filtration was performed. If a sample is not filtered, colloidal material containing chromium might be included in the analysis, which tends to result in higher reported chromium concentration than is actually present in the dissolved phase in the sample. In addition, detection limits were highly variable, tending to be lower in more recent data as analytical methods have improved. In this evaluation, emphasis was placed on total chromium data reported as dissolved (i.e., filtered).

Some samples were also specifically analyzed for Cr(VI). These data are not as prevalent as total chromium, but were used where available. Because of the higher solubility of Cr(VI) compounds, the presence of colloids is not as much of an issue as for total chromium, so all Cr(VI) data were considered representative of dissolved Cr(VI) concentrations. Laboratory analysis methods for Cr(VI) have evolved over time, so that only post-1998 samples have detection limits consistently below approximately 10 µg/L. In general, total chromium and Cr(VI) concentrations, where analyzed together, are about equal.

2.2 General Chemistry

Typical groundwater chemistry in SFV is dominated by calcium and bicarbonate. The total dissolved solids concentrations are typically 250 to 550 milligrams per liter (mg/L), with a mean of approximately 400 mg/L and a standard deviation of about 150 mg/L. This water chemistry is fairly consistent throughout the region and with depth. Chromium data collected with general chemistry data were queried from the existing SFV database. Within the study area, there do not appear to be consistent general chemistry differences between samples containing elevated chromium, lower chromium concentrations, and those with no detectable chromium.

2.3 Redox Conditions

The redox state of the aquifer is a measure of whether the subsurface conditions will tend to oxidize or reduce chemicals that exist there. In redox reactions, electrons are transferred from the oxidized species to the reduced species. Chromium species in a more reduced state tend to form insoluble complexes and are less mobile in the subsurface environment, while chromium species in a more oxidized state tend to be more soluble, and therefore more mobile in groundwater.

The redox conditions present in groundwater, along with pH, determine the chromium dominant valence state. Redox potential (Eh) is typically expressed in units of millivolts (mV). At pH 7, Cr(VI) is dominant at Eh values above 600 mV, assuming redox equilibrium. An Eh of 600 mV is considered moderately to strongly oxidizing (suboxic to oxic). In natural groundwater systems, this equilibrium state is rarely encountered, but examining other redox-sensitive species such as dissolved oxygen, nitrate, ammonia, manganese, iron, sulfate, sulfide, and organic carbon is useful in estimating the potential of the system to reduce or oxidize chromium. At pH 7 and an Eh of 600 mV, dissolved oxygen and nitrate would not be present in typical natural waters, as conditions would not be oxidizing enough for their stability (Schwartzbach et al., 1993). By contrast, pH 7 and an Eh of 600 mV would be too oxidizing for dissolved iron, manganese, sulfide, or organic carbon to be thermodynamically stable. Given these theoretical relationships, the presence of abundant oxygen and nitrate would indicate a redox state favorable for Cr(VI), whereas the presence of reductants such as iron, manganese, sulfide, or organic carbon would indicate conditions favoring Cr(III). Redox equilibrium among all these groups is rarely encountered in natural systems, but the data may be combined to determine the most likely condition for chromium speciation.

With few exceptions, concentrations of dissolved iron and manganese in the study area are below or near analytical detection limits, which suggests that redox conditions are more oxidizing than those that would allow the stability of iron and manganese. In addition, elevated nitrate concentrations are found in most wells in the study area, suggesting that this more oxidized form of nitrogen is stable in groundwater. Dissolved oxygen is also found in samples with available data. The presence of oxygen and nitrate, combined with the absence of dissolved iron and manganese, indicates an oxidizing redox environment that is likely to favor Cr(VI) over Cr(III). These redox parameters lend supporting evidence to the hypothesis that Cr(VI) is not being chemically reduced in SFV.

Nature and Extent of Contamination

This section summarizes historical trends and the recent distribution of chromium and the emerging chemicals in groundwater within the NHOU. The SFV database is updated periodically with groundwater level and groundwater quality data from the following sources:

- Remedial investigation wells – data from 84 SFV RI wells monitored by CH2M HILL for EPA.
- Lockheed-Martin monitoring wells – data from 130 wells at the Lockheed-Martin site monitored by TetraTech, Inc., (2000 - 2004 chromium data are available for only 53 of these wells).
- LARWQCB facilities – groundwater quality data for sites where LARWQCB has issued cleanup and abatement orders, and other facilities for which LARWQCB receives monitoring data. This includes data from within the NHOU such as Honeywell, Lockheed, and several landfills. Facility wells from the Burbank and Glendale OUs are also included in the database, but are not a part of this evaluation.
- LADWP – groundwater production and groundwater quality data for LADWP production wells, including and the NHOU extraction wells NHE-2 through NHE-8.

The primary focus of this evaluation is on recent data (from January 2000 through December 2004). New monitoring wells were installed at the Honeywell facility in late 2004 and early 2005. To incorporate these new wells into this analysis, additional chromium and emerging chemicals data from samples collected at the Honeywell facility that were collected through May 2005 have also been included.

3.1 Chromium

Analytical results for chromium have been reported in various ways at different times and for different sites within the SFV. For this evaluation, chromium species identified in the database as total chromium, dissolved chromium, or chromium are assumed to represent the sum of all dissolved chromium species present in a groundwater sample and are referred to herein as total chromium. The term chromium, where used without qualifiers, refers to any and all chromium species, generally. Entries in the database for “chromium-6” are assumed to represent dissolved Cr(VI). Some of the total chromium database entries, especially older data, likely include results for unfiltered samples, which would include colloidal or particulate chromium in addition to dissolved chromium.

Time series plots (chemical hydrographs) for total and hexavalent chromium data in the SFV groundwater for the NHOU, and selected wells from adjacent areas, through August 2004 are provided in Appendix A. Open circles on the time-series plots represent nondetections that are reported at the laboratory detection limits.

3.1.1 Historical and Recent Distribution of Chromium

Figures 3 and 4 indicate the highest historical (pre-2000) chromium concentrations in the NHOU for Depth Region 1 (see Figure 3), and for Depth Regions 2 through 4 (see Figure 4). These figures focus on the central portion of the NHOU, where most of the available chromium data has been collected, and where chromium concentrations have generally been the highest. Within this region, these figures include all wells for which historical chromium data are available in the SFV database. Small regions at the north and south edges of the NHOU with relatively few monitoring wells are not shown on these figures. Nondetections on these figures represent the most recent nondetections measured prior to January 1, 2000.

As Figures 3 and 4 indicate, historical exceedances of the chromium MCL have been measured at just three wells. These included monitoring well V13ALSW3 at the Honeywell facility (maximum total chromium concentration 1,400 µg/L in July 1997), and NHOU extraction wells NHE-2 (maximum total chromium concentration 97 µg/L in March 1999) and NHE-4 (maximum total chromium concentration of 60 µg/L in May 1990.) A Honeywell facility monitoring well, V13ALSW4, had a total chromium concentration equal to the MCL of 50 µg/L in February 1998.

The available historical chromium concentration data from other facilities within the NHOU, including the Penrose Landfill, Newberry Landfill, Hewitt Landfill, Tuxford Landfill, Sheldon-Arleta Sanitary, Strathern Pit, and Lockheed Aeronautics facilities, have all been nondetections with one exception. Well V14705A8, which is a Strathern Pit facility well, had a historical maximum Cr(VI) concentration of 9 µg/L in February 1999.

Lockheed monitoring well LB6-MW01, which is in the Burbank OU but near the NHOU, had a historical maximum total chromium concentration of 70 µg/L in July 1989. The other available chromium concentrations for this monitoring well have all been nondetections, although the latest available data is from January 1990. It is believed that the apparent detection at this well is a misreported nondetection, although this is impossible to verify because the total chromium detection limit for this sample is not available.

Figures 5 and 6 indicate the highest recent (January 2000 through December 2004) chromium concentrations for Depth Region 1 (see Figure 5), and for Depth Regions 2 through 4 (see Figure 6). These figures show the same extents as Figures 3 and 4, focusing on the central portion of the NHOU where most of the available chromium data has been collected. Within this region, these figures include all wells for which historical chromium data are available in the SFV database. Small regions at the north and south edges of the NHOU with relatively few monitoring wells are not shown on these figures. These figures show the most recent nondetections, measured prior to January 1, 2005. The locations of wells GW-11, GW-12A, GW-16, and GW-17 are identified on Figures 5 and 6.

As Figures 5 and 6 indicate, all of the recent measured exceedances of the chromium MCL have occurred at Honeywell facility monitoring wells and at one of the seven functioning NHOU extraction wells. The Honeywell facility monitoring wells with recent MCL exceedances include V13ALSW1, V13ALSW3, V13ALSW5, V13ALSW7, V13ALSW9, V13ALS10, GW-14A, and GW-14B. The maximum recent (2000 through 2004) concentration at the Honeywell facility was 15,000 µg/L chromium at V13ALS10 (sample date September 2004).

The one NHOU extraction well with recent MCL exceedances is NHE-2. This well had a maximum total chromium concentration of 61.4 µg/L (April 2002 sample). Chromium results from recent samples from facilities other than Honeywell are not present in the database.

The historical and recent chromium concentrations on Figures 3 through 6 suggest that the Honeywell facility has been a source of chromium contamination which exceeds the MCL in groundwater since at least the late 1990's. Other sources of chromium contamination which exceed the MCL within the NHOU are not identifiable by these data.

Figures 7 and 8 show chromium concentrations over time in the NHOU in Depth Region 1 and in Depth Regions 2 through 4 respectively. Relatively few chromium concentration data are available prior to 1998, especially for Cr(VI). At most monitoring and production wells in the NHOU, reported Cr(VI) concentrations were similar to total chromium concentrations, indicating that most of the chromium dissolved in groundwater consists of Cr(VI). Total chromium concentrations have been higher than Cr(VI) concentrations at Honeywell site monitoring wells V13ALSW2, V13ALSW6, and V13ALSW9, suggesting that a significant fraction of chromium in these samples might exist in the trivalent state. However, if water samples from these wells were turbid and inadequately filtered, they might have been excessively influenced by colloidal or suspended Cr(III) and, therefore, the total chromium results might not be representative of dissolved concentrations.

The highest concentrations of total and Cr(VI) in Depth Region 1 in the vicinity of the NHOU treatment system (up to 9,000 µg/L in the recent period) occur at the Honeywell site monitoring wells (see Figure 7). Concentrations of total chromium and Cr(VI) ranging from 5 to 100 µg/L have been detected at nearby NHOU extraction well NHE-2, and concentrations ranging from 3.5 to 14.1 µg/L have been detected at NHE-3, -4, -5, and -6.

Concentrations approaching 10 µg/L have also been detected at shallow RI monitoring wells NH-VPB-02 and -03, located southwest of the NHOU extraction wellfield (see Figure 7). Chromium concentrations were approximately 2 µg/L at most of the remaining NHOU monitoring and production wells screened in Depth Region 1.

In the deeper groundwater zones in the NHOU, total chromium and Cr(VI) have typically been detected at concentrations of approximately 2 µg/L at most production and monitoring wells. Somewhat elevated concentrations of total chromium and Cr(VI) (up to 7 µg/L) have been detected at production wells west of the NHOU extraction system, including most of the wells in the north part of the North Hollywood West wellfield.

Figures 9 and 10 are cross sections, which include well screen depths and chromium concentration time series plots. The transect (A-A') shown on Figure 11 begins in the Rinaldi-Toluca wellfield, passes through the southwest portion of the Honeywell facility, and continues southeast through the NHOU extraction wellfield. Transect A-A' changes direction approximately 100 feet west of NHE-6, and ends at NHOU extraction well NHE-8.

In general, chromium concentrations have been less than 5 µg/L at the Rinaldi-Toluca production wells, which are screened in Depth Regions 2 and 3. Chromium concentrations have been higher than this in most of the Honeywell facility wells, of which the onsite wells (older wells without Barcads) are all screened in Depth Region 1. Chromium concentrations

have recently been on the magnitude of thousands of micrograms per liter at monitoring wells V13ALSW3 and V13ALS10. Similarly, the NHOU extraction wells along the transect, which are screened in Depth Region 1, also have higher concentrations than wells screened at greater depths. This distribution of contamination is typical of alluvial basins, where layered sediments tend to promote horizontal migration of contaminants over vertical migration. It should be noted, however, that the prevalent downward hydraulic gradient that exists throughout the NHOU will drive downward migration of contaminants where the stratigraphy is conducive to significant vertical flow. Increasing or decreasing chromium trends through time at individual wells are not distinct along this cross section. Detected concentrations have tended to remain within the same order of magnitude during the period of record for these NHOU wells, and the observed variability in concentrations appears to reflect random variations more than notable trends. However, there is a common pattern among many of the North Hollywood West production wells, where positive detections of chromium concentrations from 1 to 3 µg/L in 1999 through early 2001 turned into nondetections (less than 1 µg/L) in late 2001 through 2002. This pattern is observed at production wells 4909G, 4909H, 4909J, 4909L, and 4909M.

The transect (B-B') on Figure 10 begins in the North Hollywood West production wellfield, passes northeast through the Honeywell facility, and ends at Lockheed facility monitoring well LC1-CW02, which is northwest of the Burbank Airport. Similar to A-A', the general pattern is of lower concentrations at the production wells, and higher concentrations at several of the shallower Honeywell facility monitoring wells. Individual wells do not indicate particularly strong increasing or decreasing trends, in part due to the relatively short time series that are available at most wells. Several of the production wells of the North Hollywood West wellfield, including wells 3790C, 3790G, 3790H, 3790J, and 3790M, appear to consistently have slightly elevated chromium concentrations, up to 7 µg/L, compared to the more typical 1 to 3 µg/L at most deeper monitoring and production wells in the NHOU. The origin of these slightly elevated chromium concentrations is unknown at this time, due in part to uncertainty regarding the extent of the capture zone of these production wells, and to uncertainty about local hydraulic gradients.

3.1.2 More Recent Honeywell Facility Monitoring Well Chromium Data

In late 2004 and early 2005, Honeywell installed four new wells in an OIA, southwest of the former Honeywell facility (MWH, 2005). Groundwater samples were collected via SimulProbe® (grab samples) during installation. Multiple Barcad sampling devices were installed in each of these wells. The first (baseline) Barcad sampling occurred in intermittent sampling events between March and early May 2005. The second Barcad sampling event occurred during a May 23 to May 25 2005 facility-wide groundwater sampling event in which samples were collected from all active Honeywell site monitoring wells. The offsite monitoring wells each have multiple screen intervals. Wells GW-11 and GW-16 are screened in Depth Regions 1 through 3; the multiple screen intervals of wells GW-12A and GW-17 are constructed entirely within Depth Region 2.

Table 3-1 lists the Cr(VI) concentrations that were measured in the grab samples that were collected during drilling activities, followed by the total chromium and Cr(VI) concentrations that were measured from the first round of Barcad samples. The Cr(VI) concentrations measured in the grab samples were mostly nondetections (less than 1 µg/L), with some

exceptions. Four groundwater samples collected at GW-11 between 273 and 326.5 feet bgs had Cr(VI) concentrations exceeding the total chromium MCL, while two samples collected at this location below 400 feet bgs had nondetect Cr(VI) concentrations. The uppermost groundwater sample collected at GW-16, at 271 feet bgs, had a Cr(VI) concentration of 39 µg/L. These offsite chromium concentrations suggest that chromium may be migrating southward from the Honeywell site.

TABLE 3-1

Chromium Concentrations in Preliminary Samples Collected from Honeywell Offsite Investigation Area Monitoring Wells
North Hollywood Operable Unit Chromium Evaluation

Well ID	Sample Depth (feet bgs)	Sample Date	Total Chromium (µg/L)	Cr(VI) (µg/L)
During Drilling Activities (Grab Samples)				
GW-11	273	03/24/05	NA	150
	273 (Duplicate)	03/24/05	NA	150
	281	03/24/05	NA	80
	291.5	03/25/05	NA	420
	326.5	03/28/05	NA	120
	409.5	03/30/05	NA	<1
	454	03/30/05	NA	<1
GW-12A	290	12/03/04	NA	<1
	300	12/06/04	NA	<1
	310	12/07/04	NA	<1
	330	12/07/04	NA	<1
	340	12/07/04	NA	<1
	350	12/08/05	NA	<1
	360	12/08/05	NA	<1
GW-16	271	02/24/05	NA	39
	281	02/28/05	NA	<1
	281 (Duplicate)	02/28/05	NA	<1
	291	02/28/05	NA	<1
	301	03/01/05	NA	<1
	327	03/03/05	NA	<1
	414.5	03/07/05	NA	<1
	454	03/08/05	NA	<1
	496.5	03/09/05	NA	<1
GW-17	279	02/07/05	NA	<1
	279 (Duplicate)	02/07/05	NA	<1
	282	02/04/05	NA	<1
	288.5	02/07/05	NA	<1
	298.5	02/07/05	NA	<1
	308.5	02/08/05	NA	<1
	317	02/08/05	NA	<1
	328	02/10/05	NA	<1
	339	02/10/05	NA	<1
	349	02/11/05	NA	<1

TABLE 3-1

Chromium Concentrations in Preliminary Samples Collected from Honeywell Offsite Investigation Area Monitoring Wells
North Hollywood Operable Unit Chromium Evaluation

Well ID	Sample Depth (feet bgs)	Sample Date	Total Chromium (µg/L)	Cr(VI) (µg/L)
After Well Development (Pre-Barcad Samples)				
GW-12A	280	12/27/04	NA	<1
	320	12/27/04	NA	<1
	350	12/27/04	NA	<1
Baseline Samples (After Barcads Installed)				
GW-11	273	05/04/05	150	<1
	287	05/04/05	120	<1
	316	05/04/05	95	<1
	352	05/04/05	18	1.1J
	407	05/04/05	<5	<1
	438	05/04/05	NA	<1
GW-12A	287	03/29/05	67	64
	322	03/29/05	<5	1.7
	350	03/28/05	<5	<1
GW-16	277	05/05/05	<5	<1
	317	05/06/05	13	<1
	346	05/05/05	<5	<1
	416	05/06/05	<5	<1
	507	05/06/05	<5	1.3
	556	05/06/05	<5	1.1
GW-17	288	04/06/05	<5	<1
	323	03/25/05	<5	<1
	346	03/30/05	<5	<1

Source: MWH, 2005a

Notes:

DUP = Duplicate sample listed below original sample

J = Result is estimated

NA = Not analyzed

< = Less than (not detected above the laboratory report limit shown)

There is some uncertainty regarding the representativeness of reported chromium concentrations in samples collected from the Barcad samplers, which may have been impacted by the drilling process. Two of the wells, GW-11 and GW-16, were drilled using mud rotary in response to persistent heaving sand below the water table. Wells GW-12 and GW-17 were drilled with air rotary. Grab samples collected from wells GW-11 and GW-16 during well construction yielded Cr(VI) concentrations approximately 2 orders of magnitude greater than Barcad samples subsequently collected (e.g., 170 µg/L versus 1.7 µg/L in GW-11). Wells GW-12 A and GW-17 do not show this discrepancy. The Barcad sample collected from GW - 12A is 64 µg/L, and the grab sample was below detection limits. These results suggest the possibility that mud remaining in the formation surrounding wells GW-11 and GW-16 is causing reducing conditions, resulting in nonrepresentative sampling results. However,

despite the uncertainty in exact concentrations, results clearly suggest that elevated Cr(VI) concentrations are present in the aquifer in the vicinity of several of the offsite monitoring wells.

According to the *Groundwater Monitoring Report, Second Quarter 2005* (MWH, 2005), it often takes a few sampling events for Barcad samples to yield results that are fully representative of aquifer conditions. Therefore, a cautious approach toward drawing inferences about chromium concentrations in the surrounding aquifer based on the Barcad monitoring well sampling results is warranted at this time. This includes results from wells GW-11, GW-12A, GW-16, and GW-17.

The total chromium and Cr(VI) concentrations from the May 23 to May 25, 2005 sampling event at the Honeywell site are indicated on Figures 11 and 12 and in Table 3-2. These data indicate that total chromium was not detected in several onsite and offsite wells at the Honeywell facility. However, concentrations in excess of the total chromium MCL of 50 µg/L have been measured at monitoring wells V13ALSW3, V13ALSW7, V13ALS10, GW-12A, GW-14A, and GW-15. Most of these locations are within the Honeywell site. Well GW-12A is located offsite (see Figures 11 and 12) and the sample with the highest concentration at this location (270 µg/L) was collected from 319 feet bgs, which is in Depth Region 2. The Cr(VI) concentration from this sample was also 270 µg/L. These results suggest that chromium concentrations in the vicinity of the offsite wells have reached a maximum depth of approximately 320 feet bgs, indicating horizontal and vertical offsite migration of dissolved chromium. Samples from greater depths in the offsite area are non-detect for chromium, but it is possible that chromium contamination has reached greater depths farther downgradient from the Honeywell Site. The highest known chromium concentrations in the NHOU were measured in samples collected from monitoring well GW-15, where the total chromium concentration was 9,200 µg/L and the Cr(VI) concentration was 11,000 µg/L in May 2005.

3.2 Emerging Contaminants

Available data for several emerging contaminants of potential concern were reviewed as part of this investigation, including the following:

- TCP
- 1,4-Dioxane
- MTBE
- NDMA
- Perchlorate
- Thallium

Too few samples have been obtained to date to determine whether these emerging contaminants are migrating or increasing in concentration in the NHOU; therefore, further monitoring will be necessary to reliably project future trends in emerging contaminant concentrations.

TABLE 3-2

Total and Hexavalent Chromium Concentrations from Samples Collected at the Honeywell Site during the May 23, to May 25, 2005 Sampling Event
North Hollywood Operable Unit, Chromium Evaluation

Well	Sample Depth (feet bgs) ^a	Sample Date	Total Chromium Concentration (µg/L)	Cr(VI) Concentration (µg/L)
V13ALSW1	271	05/24/05	ND	2
V13ALSW2	275	05/23/05	ND	1.2
V13ALSW3	275	05/24/05	310	330
V13ALSW4	278	05/26/05	ND	ND
V13ALSW5	275	05/25/05	ND	ND
V13ALSW6	270	05/23/05	ND	ND
V13ALSW7	265	05/25/05	400	470
V13ALSW8	263	05/23/05	ND	ND
V13ALSW9	270	05/24/05	ND	ND
V13ALS10	275	05/25/05	290	340
GW-11	273	05/25/05	53	ND
GW-11	287	05/25/05	50	ND
GW-11	316	05/25/05	44	ND
GW-11	352	05/25/05	ND	ND
GW-11	407	05/25/05	ND	ND
GW-11	438	05/25/05	ND	ND
GW-12A	284	05/23/05	5.4	5.5
GW-12A	319	05/23/05	270	270
GW-12A	349	05/23/05	ND	ND
GW-14A	270	05/24/05	260	270
GW-14B	298.5	05/24/05	ND	2.7
GW-15	287.5	05/24/05	9200	11000
GW-16	277	05/24/05	ND	ND
GW-16	317	05/24/05	ND	ND
GW-16	347	05/24/05	ND	ND
GW-16	417	05/24/05	ND	ND
GW-16	507	05/24/05	ND	ND
GW-16	558	05/24/05	ND	ND
GW-17	282	05/23/05	ND	ND
GW-17	317	05/23/05	ND	ND
GW-17	342	05/23/05	ND	ND

^aSample depths shown are the midpoints of the screened intervals or the reported depths of the Barcad samplers, as appropriate.

Note:

ND = not detected

The May 2005 emergent chemical concentrations at the Honeywell site are listed in Table 3-3. These concentrations are discussed in the following subsections for each constituent. According to the *Groundwater Monitoring Report, Second Quarter 2005* (MWH, 2005), it often takes a few sampling events for Barcad samples to yield results that are fully representative of aquifer conditions. Therefore results from the May 2005 Barcad monitoring well sampling results might not be representative of actual contaminant concentrations. This includes results from wells GW-11, GW-12A, GW-16, and GW-17.

TABLE 3-3

Emerging Contaminants Concentrations from Samples Collected at the Honeywell Site during May 2005
North Hollywood Operable Unit Chromium Evaluation

Well	Sample Depth ^a	Sample Date	1,2,3-TCP Concentration (µg/L)	1,4-Dioxane Concentration (µg/L)	NDMA Concentration (µg/L)	Perchlorate Concentration (µg/L)	Thallium Concentration (µg/L)
V13ALSW1	271	05/24/05	<1	NA	NA	NA	<1
V13ALSW2	275	05/23/05	<1	3.9	NA	<2	<1
V13ALSW3	275	05/24/05	<1	4.9	NA	2.5	<1
V13ALSW4	278	05/26/05	<1	NA	NA	NA	<10
V13ALSW5	275	05/25/05	<1	NA	NA	NA	<10
V13ALSW6	270	05/23/05	<1	4.9	NA	<2	<1
V13ALSW7	265	05/25/05	<1	5.1 ^b	NA	<2	<10
V13ALSW8	263	05/23/05	<1	NA	NA	NA	<1
V13ALSW9	270	05/24/05	<1	NA	NA	NA	<1
V13ALS10	275	05/25/05	<1	1.9	NA	<2	<10
GW-11	273	05/25/05	<0.005	<1 ^b	0.0023	<10	<1
GW-11	287	05/25/05	<0.005	<1 ^b	0.0035	<10	<1
GW-11	316	05/25/05	<0.005	<1 ^b	0.0036	<10	<1
GW-11	352	05/25/05	<0.005	1.1	<0.0020	<2	<1
GW-11	407	05/25/05	<0.005	<1 ^b	<0.0020	<10	<1
GW-11	438	05/25/05	<0.005	<1 ^b	0.0055	<10	<1
GW-12A	284	05/23/05	<1	3.4	0.0020	<2	<1
GW-12A	319	05/23/05	<1	2.9	<0.0020	<2	<1
GW-12A	349	05/23/05	<1	<1 ^b	<0.0020	<2	<1
GW-14A	270	05/24/05	<1	NA	NA	NA	<1
GW-14B	298.5	05/24/05	<1	NA	NA	NA	<1
GW-15	287.5	05/24/05	<1	16	NA	14	<1
GW-16	277	05/24/05	<1	1.2	<0.0020	<2	<1
GW-16	317	05/24/05	<1	<1 ^b	<0.0034 ^b	<2	<1
GW-16	347	05/24/05	<1	<1 ^b	<0.0029 ^b	<2	<1
GW-16	417	05/24/05	<1	<1 ^b	<0.0060 ^b	<2	<1
GW-16	507	05/24/05	<1	<1 ^b	<0.0020	<2	<1
GW-16	558	05/24/05	<1	<1 ^b	0.0029	<2	<1
GW-17	282	05/23/05	<1	2.2	<0.0020	<2	<1
GW-17	317	05/23/05	<1	2.5	<0.0120 ^b	<2	<1
GW-17	342	05/23/05	<1	1.1	<0.0038 ^b	<2	<1

^aSample depths shown are the midpoints of the screened intervals or the reported depths of the Barcad samplers, as appropriate.

^bEstimated result.

Notes:

< = Less than (nondetection with the detection limit shown)

NA = Not analyzed

3.2.1 1,2,3-Trichloropropane

The State of California established a notification level of 0.005 µg/L (equivalent to the current detection limit) for 1,2,3-TCP in 1999, after it was detected in groundwater in the Burbank OU. Neither DHS nor EPA have established an MCL for 1,2,3-TCP in drinking water. 1,2,3-TCP has been used as a solvent and pesticide ingredient. DHS lists 1,2,3-TCP as a known carcinogen.

1,2,3-TCP has been detected at 12 wells in or adjacent to the NHOU in 20 groundwater samples. The highest concentrations (ranging from 0.02 to 730 µg/L) were detected at Lockheed monitoring wells 3831Q, LC1-CW05, and NHOU RI wells NH-C02-325 and NH-C02-520, located south of Burbank Airport along the boundary between the NHOU and the Burbank OU. Lower concentrations, ranging from the detection limit (0.005 µg/L) to 0.016 µg/L, have been detected at Honeywell site monitoring wells V13ALSW1 through V13ALSW7 and at V13ALSW10. The most recent available sample results, from May 2005, indicate that 1,2,3-TCP was not detected at any of the Honeywell site wells. However, for many of the samples, the analytical detection limit used by Honeywell was 1 µg/L, which is too high for meaningful comparison to the 0.005 µg/L state notification level. In response to recent detection of 1,2,3-TCP in DWP well NHE-5, EPA has directed Honeywell to use an analytical method in the future that will detect 1,2,3-TCP at the state notification level.

3.2.2 1,4-Dioxane

The State of California established a drinking water notification level of 3 µg/L for 1,4-dioxane in 1998. Neither DHS nor EPA have established an MCL for 1,4-dioxane in drinking water. 1,4-Dioxane has been used as a solvent stabilizer and is found in many human-made substances and several natural materials. The EPA lists 1,4-dioxane as a probable human carcinogen.

1,4-Dioxane was not detected in most samples collected in December 2002 from selected RI monitoring wells in the NHOU; however, it was detected at deep RI monitoring well NH-CO3-580 at a concentration of 3 µg/L. Most detections of 1,4-dioxane in the NHOU to date have occurred at Honeywell site monitoring wells V13ALSW1 through V13ALSW10, at concentrations ranging from 1 to 32 µg/L.

In May 2005, the highest concentrations of 1,4-dioxane at the Honeywell site were measured in the sample from well GW-15 (16 µg/L), which was also the location of the highest total chromium, Cr(VI), and perchlorate concentrations during that sampling event. One offsite sample, from monitoring well GW-12A at 284 feet bgs, had a 1,4-dioxane concentration of 3.4 µg/L, which slightly exceeds the state drinking water notification level.

3.2.3 Methyl Tert Butyl Ether

In 2000, the State of California established primary and secondary MCLs for MTBE of 13 and 5 µg/L, respectively because of health concerns and their odor and taste affects on drinking water. MTBE is a common gasoline additive (oxygenate), but is being phased out of use in California because of the extensive groundwater contamination resulting from its use.

Data on MTBE are available for many wells in the SFV database; however, only three trace detections (less than 1 µg/L) have been reported. MTBE was not detected in the vast majority of samples from the NHOH for which it was analyzed.

As discussed in Section 2.3, the results of a November 2004 sampling event were that MTBE was not detected at any of the Honeywell site monitoring wells. The May 2005 groundwater samples from the Honeywell site monitoring wells were not analyzed for MTBE.

3.2.4 n-Nitrosodimethylamine

The State of California revised the drinking water notification level for NDMA in 2002 to 0.01 µg/L. Neither DHS nor EPA has established an MCL for NDMA in drinking water. It has been used in the production of rocket fuel and for other industrial processes. The DHS lists NDMA as a known human carcinogen.

Relatively few samples of groundwater from wells in the NHOH have been analyzed for NDMA. The samples that were analyzed have all been from facility monitoring wells and well 3830S (sampled by Lockheed). All NDMA detections in the NHOH to date have occurred at Honeywell site monitoring wells V13ALSW1 through V13ALSW10, at concentrations ranging from 0.0022 to 1.06 µg/L.

Samples collected in May 2005 from the OIA monitoring wells were analyzed for NDMA, but the samples collected from the onsite monitoring wells were not analyzed. The offsite monitoring well samples had concentrations ranging from nondetect (at several locations) to 0.0055 µg/L at GW-11, at 438 feet bgs (the upper portion of Depth Region 3). Four of the six sample intervals at GW-11 had positive detections of NDMA. Because of the limited sampling and analysis for NDMA outside of the Honeywell site, it should not be assumed that the Honeywell site is the sole source for the NDMA or the only location where it is present.

3.2.5 Perchlorate

The State of California revised the drinking water notification level for perchlorate to 6 µg/L (formerly 4 µg/L) in 2004. Neither DHS nor EPA has established an MCL for perchlorate in drinking water. Perchlorate is a solid propellant in rockets and fireworks and has been used for other industrial processes. The primary health concern regarding perchlorate is interference with human thyroid function.

Groundwater samples from most RI monitoring wells in the NHOH and all Honeywell site monitoring wells have been analyzed for perchlorate. The four detections of perchlorate to date that are above the notification level in the NHOH have occurred at Honeywell site monitoring wells V13ALSW3, V13ALSW7, V13ALSW10, and GW-15, at concentrations ranging from 8.9 to 19 µg/L.

The May 2005 perchlorate results for the Honeywell site ranged from nondetect to 14 µg/L. The one exceedance of the state drinking water notification level was measured onsite at GW-15. This is the same location as the highest chromium and 1,4-dioxane concentrations from that sampling event. Perchlorate was not detected in any OIA (i.e., Barcad) wells.

3.2.6 Thallium

The State of California and EPA have both established a drinking water MCL of 2 µg/L for thallium. Thallium occurs naturally in some groundwater and is used in the electronics and other industries. The primary health concern regarding thallium is its potential to damage the human kidney, liver, and nervous system.

Groundwater samples from most RI monitoring wells in the NHOU and all Honeywell site monitoring wells have been analyzed for thallium. However, the detection limits for most of these thallium samples have been 5 µg/L or higher, which exceeds the MCL. Dissolved thallium has been detected in the NHOU at RI monitoring well clusters NH-CO1 through NH-CO3 at concentrations ranging from 3.7 to 6.8 µg/L.

Thallium was not detected in any samples from the May 2005 sampling event at the Honeywell site. In most cases, the thallium detection limit from this sampling event was 1 µg/L, although the detection limit for a few of the samples was 10 µg/L.

Anticipated Future Trends

This section evaluates potential future trends in chromium concentrations in groundwater in the NHOH. These potential future conditions were projected using the analysis of existing spatial and temporal trends of contaminant contamination and geochemical conditions presented in Section 2.0.

4.1 Chromium

Reported chromium concentrations in groundwater suggest that one major source area for this contaminant in the NHOH is the Honeywell site. However, additional source areas could exist in the NHOH that might also contribute chromium mass to groundwater. The May 2005 sample results suggest that the source mass of chromium at the Honeywell site has not been fully depleted. However, the recent Honeywell data from Barcad samplers are subject to substantial uncertainty at this time (MWH, 2005).

As discussed in Section 2.0 of this report, chromium mobility depends on its dominant redox state in groundwater. The dominant chromium species present in groundwater in the NHOH is the oxidized hexavalent form, which is mobile in groundwater. Therefore, the dissolved chromium present in the NHOH will likely move relatively unimpeded with the native groundwater.

To evaluate future trends in chromium concentrations in the vicinity of NHOH extraction wells, it was first necessary to estimate the travel time for groundwater to move between the Honeywell site and the downgradient extraction wells. The groundwater velocity within NHOH can be calculated using the following form of Darcy's Law:

$$V = K \cdot I / Q \quad (1)$$

Where:

V = average interstitial groundwater velocity (feet/day)

K = aquifer hydraulic conductivity (feet/day)

I = horizontal hydraulic gradient (feet/foot)

Q = transport porosity (volume/volume)

To calculate a horizontal hydraulic gradient, groundwater elevation data was compared from wells at the Honeywell site, well NH-C03-680 near NHE-4, and well NH-VPB-08 further downgradient (to the southeast). The hydraulic gradient calculated between the Honeywell site and NH-C03-680 was 0.005 feet/foot, and the gradient calculated between this well and NH-VPB-08 was 0.001 foot/foot. Assuming a horizontal hydraulic conductivity of between 100 and 150 feet/day, based on aquifer testing in the area, and a transport porosity of 0.15, a groundwater velocity of between 250 and 1,800 feet/year is implied based on Darcy's Law. Values in the middle of this range are consistent with values presented in

the *Remedial Investigation of Groundwater Contamination in the San Fernando Valley, Remedial Investigation Report* (JMM, 1992).

The NHOU extraction well field is located between 1000 feet (NHE-2) and 3500 feet (NHE-6) from the Honeywell site chromium source area. Therefore, based on the groundwater velocities calculated above, groundwater leaving the source area at the Honeywell facility should require a maximum of four years to reach extraction well NHE-2 and possibly as long as fourteen years to reach NHE-6 (however it is more likely to be on the order of 5 years). This implies that it is likely that the groundwater contaminant concentrations currently observed in the NHOU extraction well field are in a state of quasi-equilibrium with the current conditions in the source area. It is likely that future chromium concentrations in the NHOU extraction wells will remain similar to those observed today, unless the dynamics within the source area change due to rising groundwater levels, changing groundwater flow directions, or other hydrologic or chemical influences. These data also suggest that if remedial actions are undertaken at the Honeywell site that significantly reduce chromium levels in groundwater, chromium concentrations in the vicinity of the NHOU extraction well field should begin to decline several years after the source zone concentrations are reduced.

The observed groundwater contaminant data was also used to estimate the amount of attenuation, or dilution, that occurs as TCE and chromium move from the Honeywell site to extraction well NHE-2. It is expected that the contaminant concentrations in extraction well NHE-2 will be lower than those observed in monitoring wells within the source area because of dispersion during transport and dilution at the production well. However, if the dilution factors are the same for TCE and chromium, then it can be assumed that both contaminants are undergoing the same attenuation processes, and no additional geochemical factors are selectively affecting chromium persistence.

Chromium and TCE contaminant concentrations were compared for Honeywell site monitoring wells V13ALS10, V13ALSW1, V13ALSW3, and V13ALSW7, and downgradient NHOU extraction well NHE-2 for the period of 1993 through 1996. Dilution factors were calculated by comparing the measured concentration in each of the Honeywell monitoring wells listed above with the measured contaminant concentration in well NHE-2. This was done for all sampling events available in the database, and the results were averaged. This analysis suggests that, on average, TCE concentrations are attenuated by a factor of 5 as the plume travels between the Honeywell site and well NHE-2, while chromium concentrations are attenuated by a factor of approximately 25. While these results may suggest that chromium is undergoing greater attenuation than that experienced by TCE during transport, it should be noted that the data sets used in the analysis are highly variable, and the differences between the calculated dilution factors may not be statistically significant.

Widespread low levels of dissolved chromium in groundwater are detected in numerous monitoring and production wells across the remainder of the NHOU in Depth Region 1 and Depth Region 2. It is unclear whether these detections of chromium reflect contamination introduced by additional, currently unidentified source areas, has traveled from the Honeywell source area, or represent background chromium concentrations leached from local naturally occurring geologic materials. The chromium concentrations observed in these wells are below 10 µg/L, significantly below the state MCL.

Currently, the hydrogeology of the NHOU and the potential influence of regional groundwater pumping on groundwater flow directions and velocities are still not well understood. In addition, the spatial and temporal coverage of chromium concentration data is limited. The EPA is currently performing an FFS for the NHOU. As part of this effort, contemporaneous groundwater elevation data, pumping data, and additional contaminant concentration data will be collected. This contemporaneous groundwater elevation data set will support the development of a groundwater modeling tool, which will help further define groundwater flow directions and velocities in the area. Groundwater contaminant data collected in 2005 will provide additional data to define contaminant distributions and trends. These additional groundwater level and contaminant data, combined with the groundwater modeling tool, will provide improved predictions of future contaminant concentration trends within the NHOU.

4.2 Emerging Contaminants

As discussed in Section 2.3, the historical and recent data regarding the concentration extents and trends of emerging contaminants are very limited. Fortunately, concentrations of these contaminants detected to date are relatively small, and most are not widespread. Insufficient analytical data exists to predict future migration patterns for these emerging contaminants.

Conclusions and Recommendations

5.1 Conclusions

The conclusions resulting from the review of available data for the NHOU, focusing on the area and contaminants likely to affect future operation of the NHOU extraction system and nearby LADWP production wellfields are presented below.

Chromium Distribution. Conclusions regarding chromium distribution include the following:

- Redox conditions in the NHOU appear to favor the stability of the more mobile Cr(VI) rather than the relatively immobile reduced form, Cr(III).
- Chromium concentrations in samples collected in May 2005 from the Honeywell site monitoring wells suggest that there is a significant chromium source mass in groundwater beneath the Honeywell site.
- The estimated travel time for groundwater contamination between the chromium source area at the Honeywell site and downgradient NHOU extraction wells is on the order of one to several years. This suggests that the dissolved chromium concentrations detected in NHOU extraction wells reflect current conditions within the source area and are not expected to change significantly in the future unless concentrations in the source area change. This could occur in response to many factors, including increasing groundwater levels that might mobilize the chromium mass currently present in the vadose zone or remedial actions conducted at the Honeywell site.
- The average attenuation factor, or dilution factor, for dissolved chromium traveling between the Honeywell site and downgradient NHOU extraction well NHE-2 is approximately 25, while the dilution factor for TCE is approximately 5. This might suggest the existence of an additional geochemical attenuation process acting on chromium that does not affect TCE during transport, but it should be noted that the data sets used in the analysis are highly variable, and the differences between the calculated dilution factors might represent sampling variability.

Emerging Contaminants. Emerging contaminants appear limited in vertical and lateral extent within the NHOU; however, they are mobile and persistent. Concentrations of some emerging contaminants have exceeded California Department of Health Services notification levels at a limited number of monitoring locations. However, concentrations of the emerging contaminants are generally below the regulatory thresholds.

NHOU Extraction System. Future increases in groundwater levels could mobilize the chromium mass currently residing in the vadose zone, causing concentrations of chromium at NHOU extraction wells to increase and possibly reach levels that would require modifications to the existing treatment process.

Groundwater Monitoring. Groundwater level measurement data are needed to provide additional groundwater flow and hydraulic gradient information.

NHOU Treatment Plant. At this time, the NHOU treatment plant is operating substantially below its design capacity for influent flow rate and VOC mass removal. It is anticipated that the plant's VOC treatment capacity is adequate to handle the design influent flow rate of 2,000 gpm.

5.2 Recommendations

Recommendations for improvements to the NHOU extraction system and future groundwater monitoring are as follows:

NHOU Treatment System. Evaluate options to increase the performance of the NHOU treatment system.

Groundwater Monitoring. Recommendations regarding groundwater monitoring include the following:

- Continue regular monitoring for chromium, emerging contaminants, and inorganic geochemical indicator parameters at the Honeywell site monitoring wells. The November 2004 and May 2005 data are valuable additions to the available chromium data. Determining the concentrations, lateral extents, and vertical extents of contaminants in this area, where the highest chromium concentrations in the NHOU have been detected, is key to forecasting future groundwater quality impacts. In addition, in the August 2005 cooperative agreement with DWP, EPA requested monitoring of chromium at all NHOU extraction wells and monitoring of 1,2,3-TCP at NHOU extraction well NHE-5, where TCP was previously detected above the notification level.
- Collect data from other possible sources of groundwater contamination in the NHOU. Groundwater quality data from these sources should be incorporated into the NHOU evaluation as they are made available. Coordination of site-specific groundwater investigations with LARWQCB will be necessary to identify the contaminant source areas.
- Install additional monitoring wells near the NHOU extraction system and surrounding production wellfields, or convert existing production wells for use as monitoring wells. The current network of RI monitoring wells is too sparse in important locations and has not been substantially modified since 1989. Key locations for additional paired monitoring wells (Depth Regions 1 and 2) are shown on Figure 13.
- Continue monthly monitoring for total chromium and Cr(VI) at the NHOU extraction wells. High concentrations of total chromium and Cr(VI) are present in groundwater at the Honeywell site, located a few thousand feet north of several NHOU extraction wells. Chromium concentrations in groundwater at these extraction wells could change rapidly in response to future groundwater level changes. Continued frequent monitoring is warranted.
- Collect contemporaneous groundwater level data sets during spring and fall at additional, essential well locations to discern seasonal fluctuations in groundwater flow

directions and gradients. Contemporaneous water level data sets are necessary to improve understanding of the hydraulic conditions and groundwater flow directions across the NHOU and in the aquifer system.

- Modify the monitoring schedule for existing and proposed monitoring wells, facility monitoring wells, and production wells as necessary to provide data at key locations and times. This should be a coordinated monitoring plan that includes triggers for increasing or decreasing sampling frequency to provide crucial data about groundwater conditions throughout the NHOU.
- Coordinate with lead agencies to ensure that efforts to clean up source areas are consistent with EPA's approach to addressing high concentrations of chromium. Remediation of source zones could substantially decrease both the contaminant concentrations at the NHOU extraction wells and the length of time the extraction system must be operated. Consistency in approach should maximize the effectiveness of remedial efforts.

SECTION 6.0

Works Cited

CH2M HILL. 1996. *Evaluation of the Past and Potential Performance of the North Hollywood Operable Unit Facility, San Fernando Valley Superfund Site, Los Angeles County, California.*

CH2M HILL. 1998. *Five-year Review Report: North Hollywood Operable Unit Facility, San Fernando Valley Superfund Site – Area 1, Los Angeles County, California.*

CH2M HILL. 2003. *Third Five-year Review Report for North Hollywood Operable Unit, San Fernando Valley (Area 1) Superfund Site, Los Angeles County, California.*

CH2M HILL. 2005. *Burbank and Glendale Operable Units, Focused Chromium Trend Study.*

James M. Montgomery, Inc. (JMM). 1992. *Remedial Investigation of Groundwater Contamination in the San Fernando Valley.*

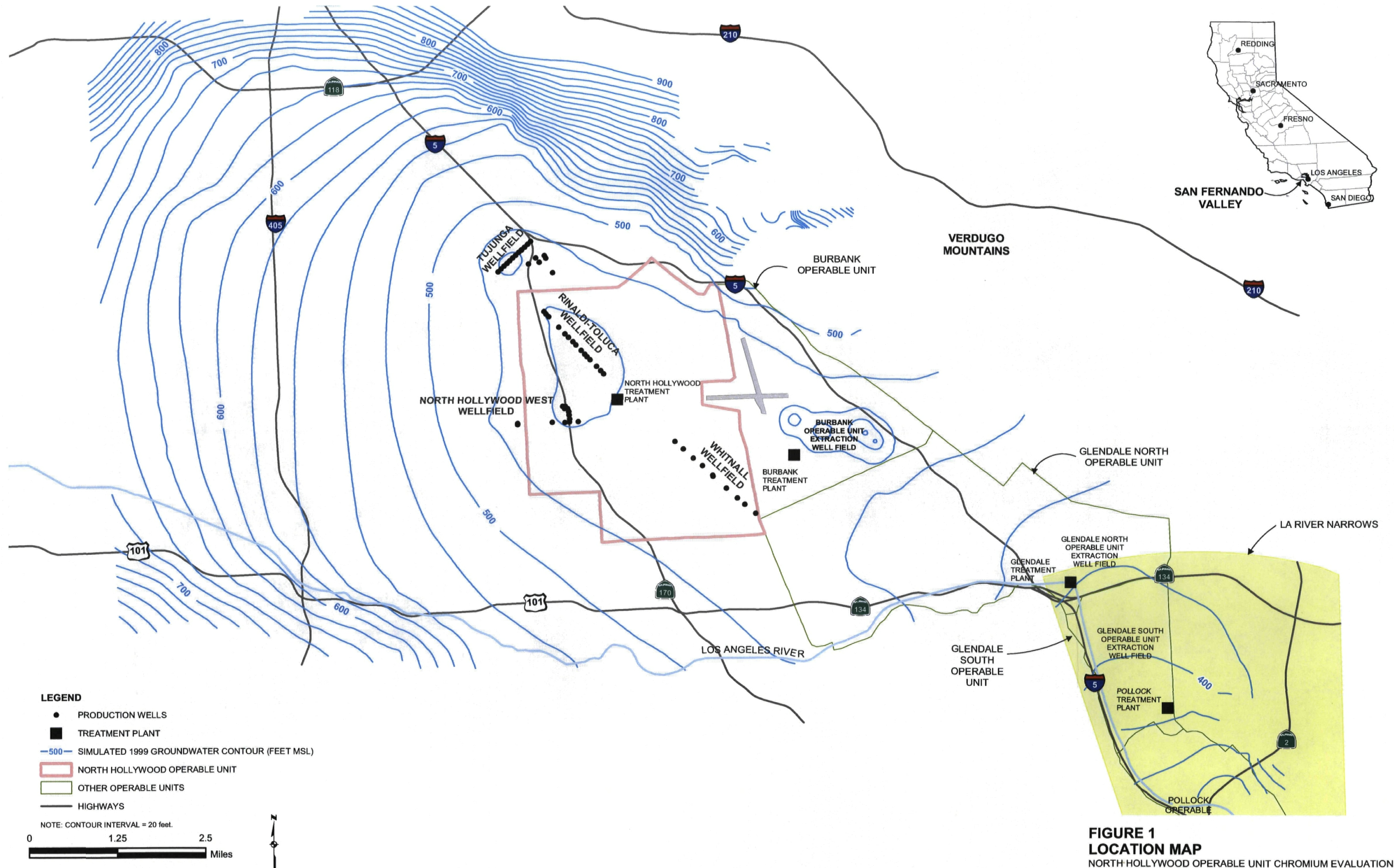
Los Angeles Department of Water and Power (LADWP). 2003. *Final Evaluation of the North Hollywood Operable Unit and Options to Enhance Its Effectiveness.*

Montgomery Watson Harza Americas, Inc. (MWH). 2005. *Groundwater Monitoring Report, Second Quarter 2005, Honeywell North Hollywood Site.*

Richard, F. C. and A. C. M. Bourg. 1991. "Aqueous geochemistry of chromium: a review." *Water Research*. 25:807-816.

Schwarzenbach, R. P., P. M. Gschwend, and D. M. Imboden. 1993. *Environmental Organic Chemistry*. New York: Wiley.

Figures



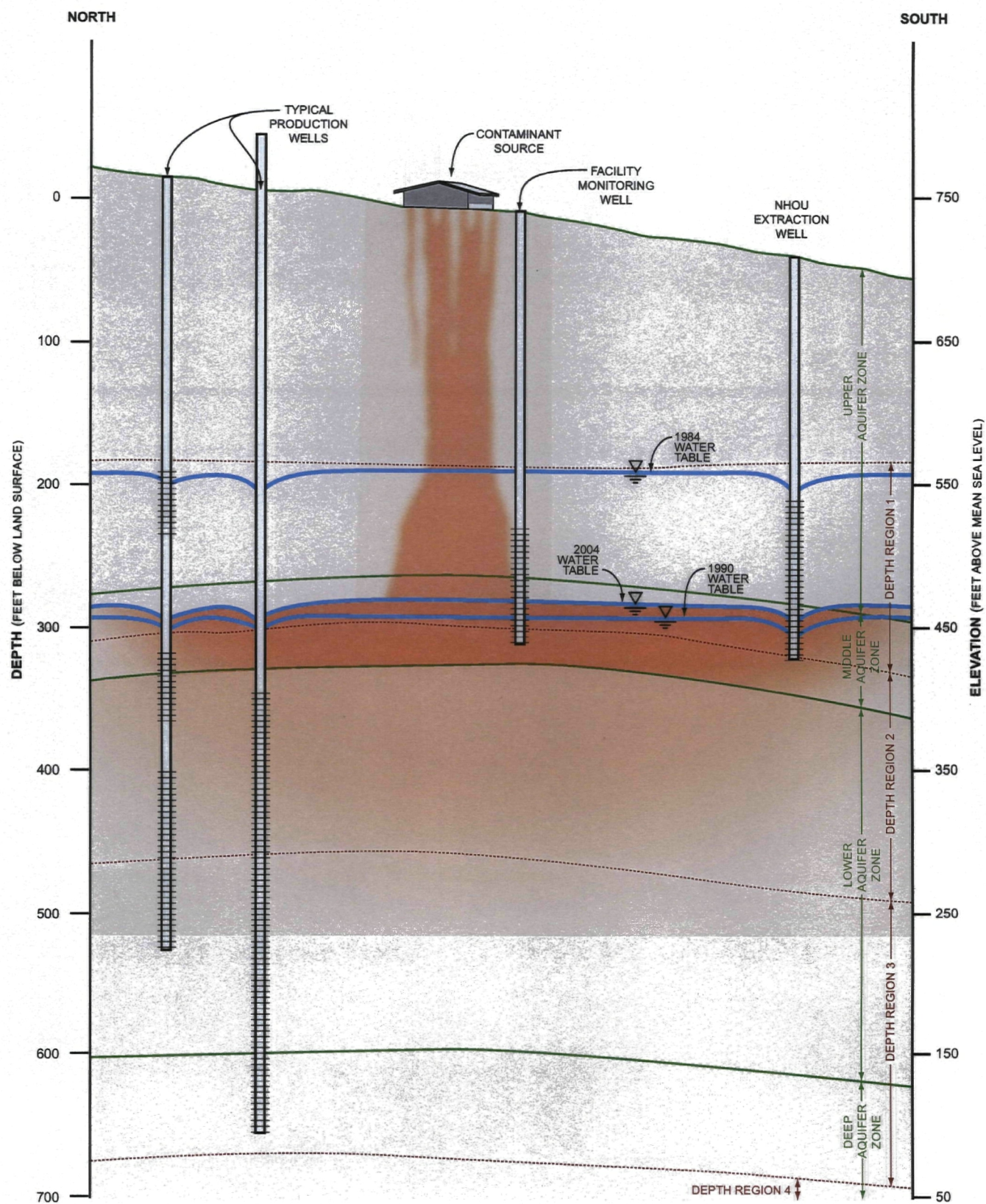
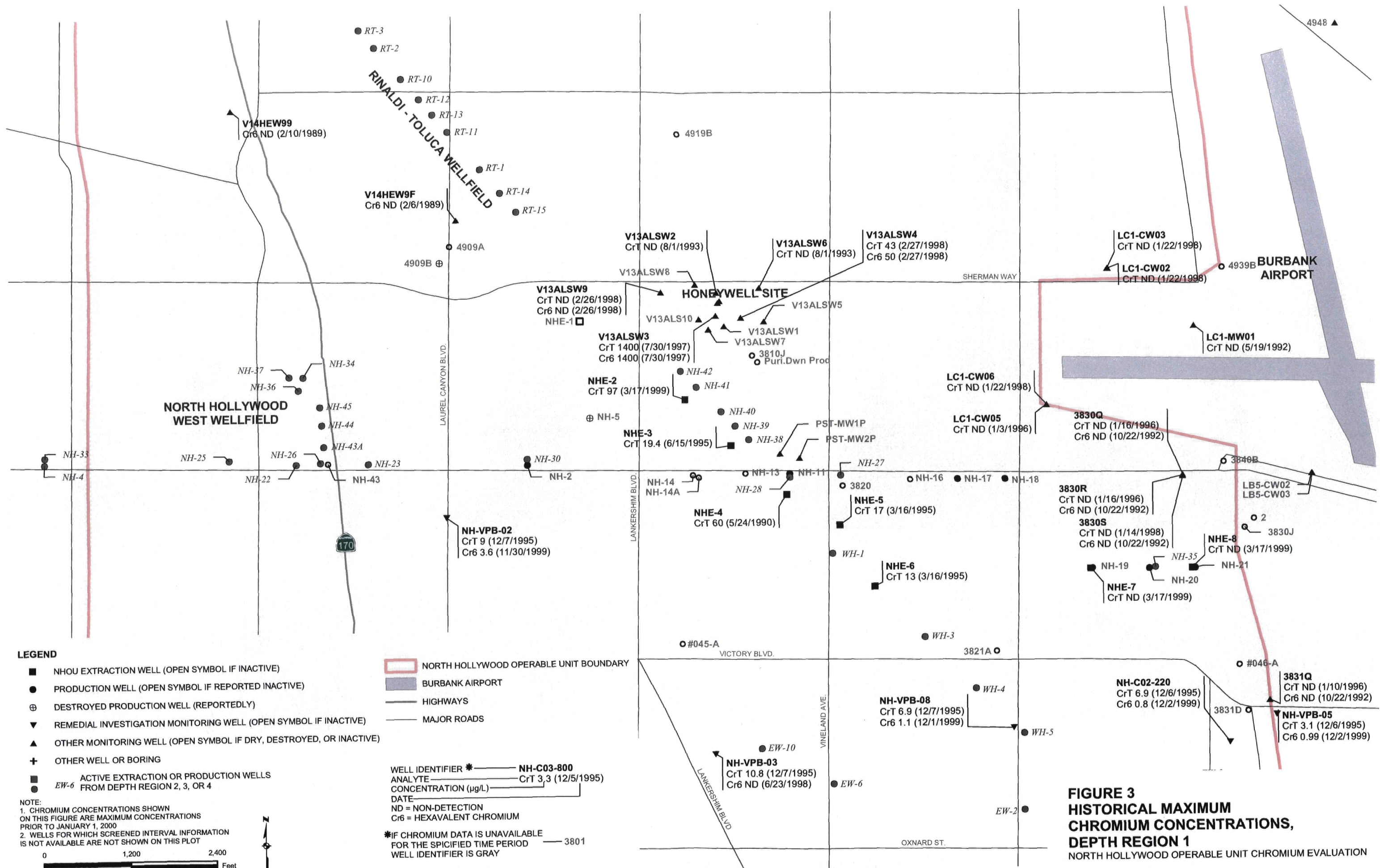
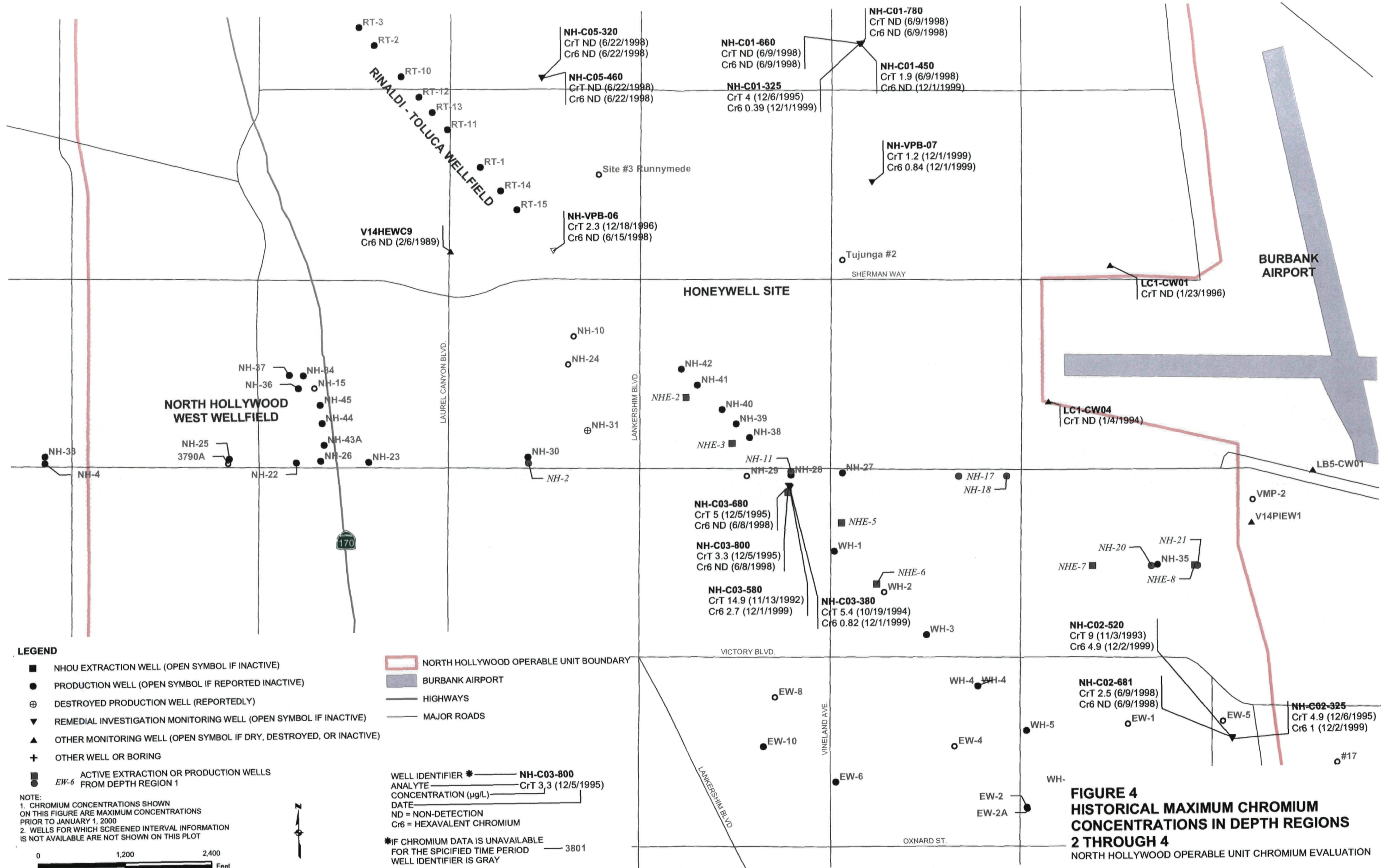
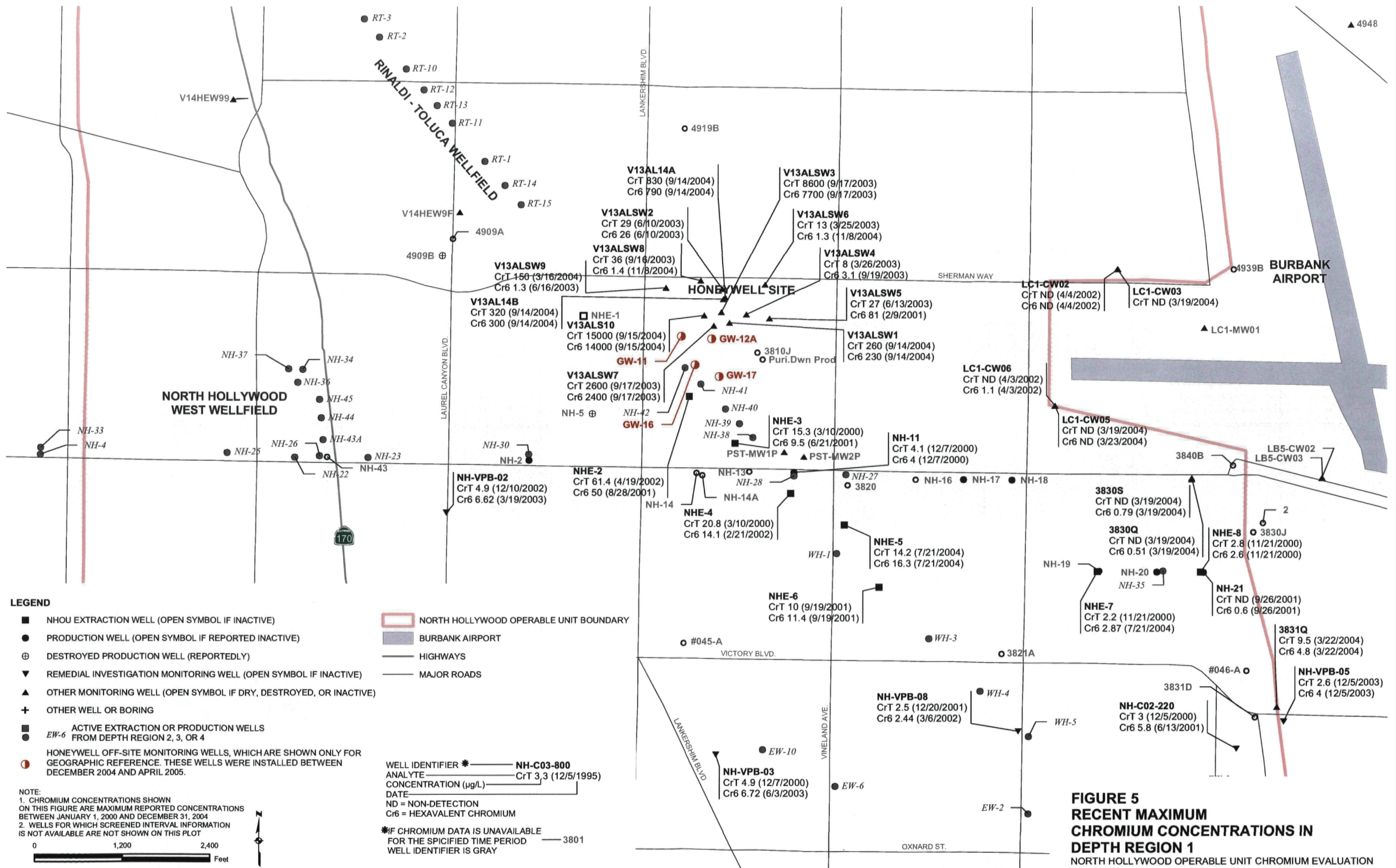
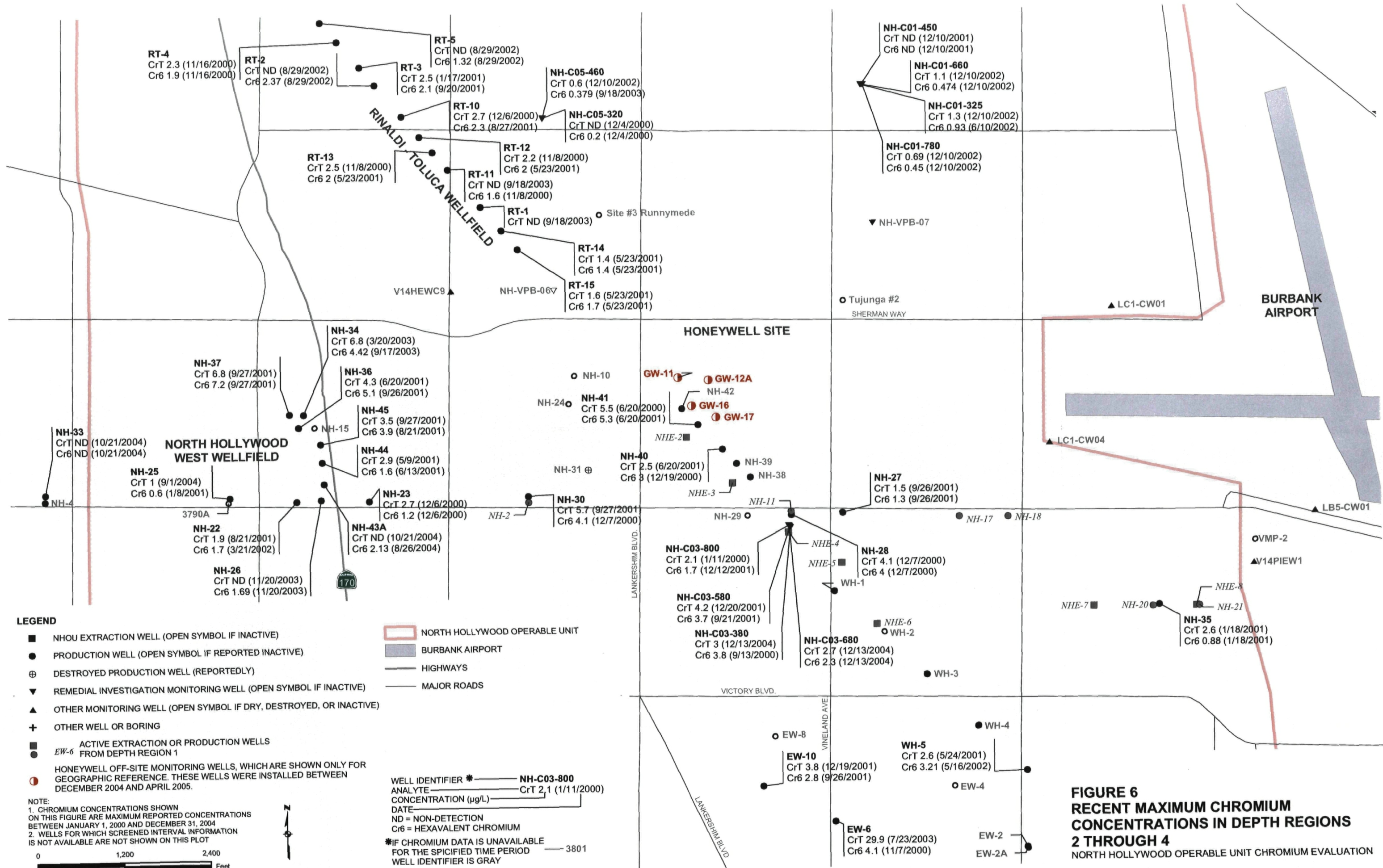


FIGURE 2
SCHEMATIC HYDROGEOLOGIC SECTION
 NORTH HOLLYWOOD OPERABLE UNIT CHROMIUM EVALUATION









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FIGURE 11
MAY 2005 TOTAL CHROMIUM
CONCENTRATIONS AT HONEYWELL SITE
 NORTH HOLLYWOOD OPERABLE UNIT CHROMIUM EVALUATION

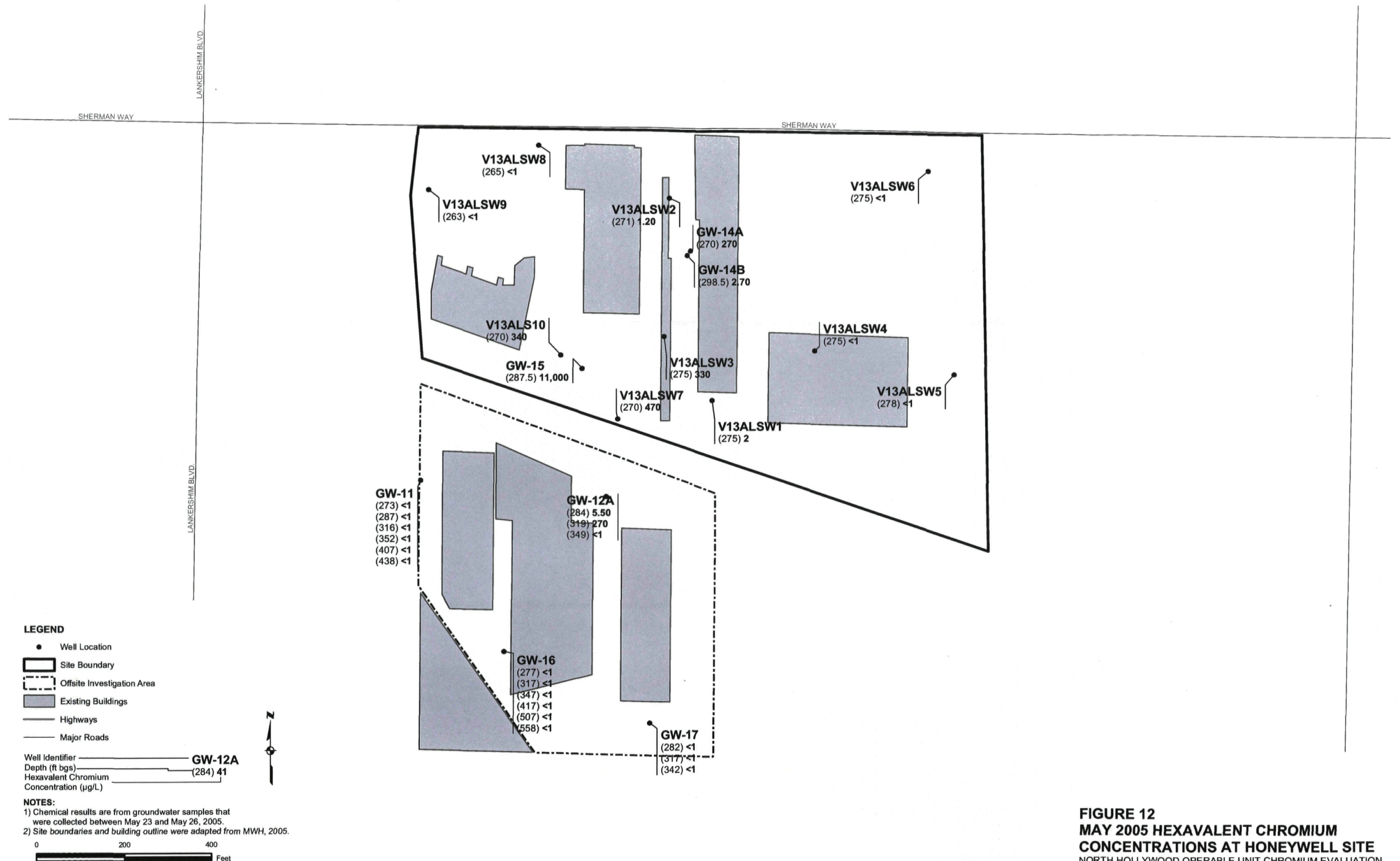
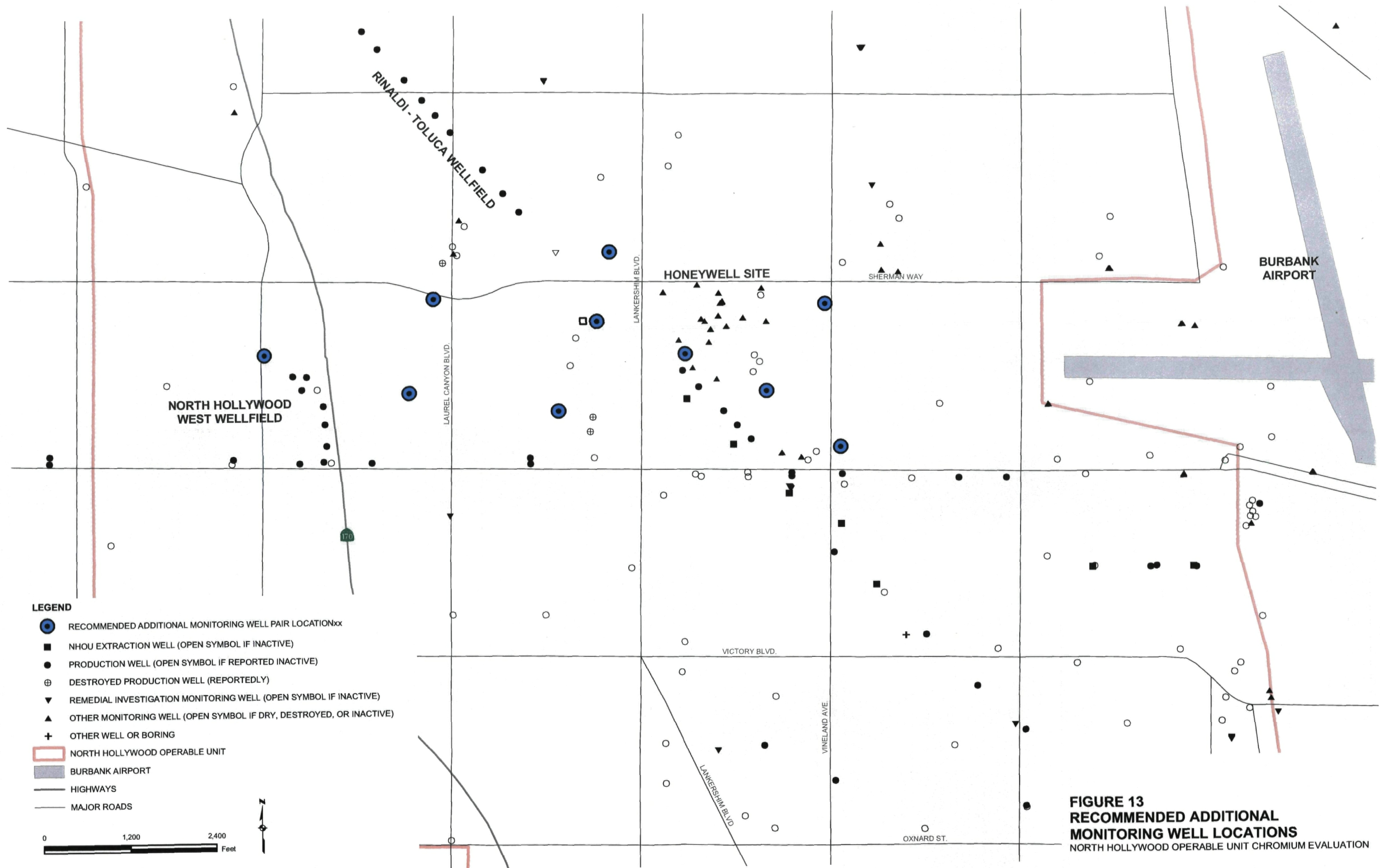


FIGURE 12
MAY 2005 HEXAVALENT CHROMIUM
CONCENTRATIONS AT HONEYWELL SITE
 NORTH HOLLYWOOD OPERABLE UNIT CHROMIUM EVALUATION



Appendix A
Chromium Time Series Plots For
North Hollywood Operable Unit and
Other Selected Wells

APPENDIX A

Chromium Time Series Plots For North Hollywood Operable Unit and Other Selected Wells

This appendix contains time series plots of chromium concentrations through August, 2004 for wells in North Hollywood Operable Unit (NHOU). Wells near (within approximately 2,000 feet) NHOU are also included, including selected wells in the Burbank Operable Unit and additional nearby wells that are outside the four operable units' boundaries. In cases where the SFV database includes multiple names for a single well, an alternate name is given in parentheses. Wells are presented in alphabetical order for NHOU, followed by the Burbank Operable Unit wells, Wells outside of the operable units are listed last.

Many wells in NHOU (production, monitoring, and extraction wells) have pseudonyms in the SFV database that are commonly used. Table A-1 lists known pseudonyms for many of the wells in NHOU. Other pseudonyms for these and other wells in NHOU might exist.

TABLE A-1

Pseudonyms of Selected Wells in North Hollywood Operable Unit
North Hollywood Operable Unit Chromium Evaluation

Primary Well Name in San Fernando Valley Database	Alternate Well Name in San Fernando Valley Database	Combined Well Name in San Fernando Valley Database	Well Owner Name in San Fernando Valley Database	Page
3770	NH-7	3770 (NH-7)	City of Los Angeles (NH WF)	23
3770C	NH-32	3770C (NH-32)	City of Los Angeles (NH WF)	23
3780A	NH-4	3780A (NH-4)	City of Los Angeles (NH WF)	23
3780C	NH-33	3780C (NH-33)	City of Los Angeles (NH WF)	23
3790C	NH-22	3790C (NH-22)	City of Los Angeles (NH WF)	6
3790D	NH-23	3790D (NH-23)	City of Los Angeles (NH WF)	6
3790E	NH-26	3790E (NH-26)	City of Los Angeles (NH WF)	6
3790F	NH-25	3790F (NH-25)	City of Los Angeles (NH WF)	6
3790G	NH-34	3790G (NH-34)	City of Los Angeles (NH WF)	6
3790H	NH-36	3790H (NH-36)	City of Los Angeles (NH WF)	6
3790J	NH-37	3790J (NH-37)	City of Los Angeles (NH WF)	7
3790K	NH-43A	3790K (NH-43A)	City of Los Angeles (NH WF)	7
3790L	NH-44	3790L (NH-44)	City of Los Angeles (NH WF)	7
3790M	NH-45	3790M (NH-45)	City of Los Angeles (NH WF)	7
3800D	NH-30	3800D (NH-30)	City of Los Angeles (NH WF)	7
3810	NH-11	3810 (NH-11)	City of Los Angeles (NH WF)	7
3810K	NH-28	3810K (NH-28)	City of Los Angeles (NH WF)	8
3810P	NH-40	3810P (NH-40)	City of Los Angeles (NH WF)	8

TABLE A-1

Pseudonyms of Selected Wells in North Hollywood Operable Unit
North Hollywood Operable Unit Chromium Evaluation

Primary Well Name in San Fernando Valley Database	Alternate Well Name in San Fernando Valley Database	Combined Well Name in San Fernando Valley Database	Well Owner Name in San Fernando Valley Database	Page
3810Q	NH-41	3810Q (NH-41)	City of Los Angeles (NH WF)	8
3810U	NHE-2	3810U (NHE-2)	City of Los Angeles (NH WF)	8
3810V	NHE-3	3810V (NHE-3)	City of Los Angeles (NH WF)	8
3810W	NHE-4	3810W (NHE-4)	City of Los Angeles (NH WF)	8
3811F	EW-10	3811F (EW-10)	City of Los Angeles (Erwin WF)	9
3820F	NH-27	3820F (NH-27)	City of Los Angeles (Erwin WF)	9
3820H	NHE-5	3820H (NHE-5)	City of Los Angeles (Erwin WF)	9
3821E	WH-5	3821E (WH-5)	City of Los Angeles (Whitnall WF)	9
3821H	EW-6	3821H (EW-6)	City of Los Angeles (Erwin WF)	9
3821J	NHE-6	3821J (NHE-6)	City of Los Angeles (Erwin WF)	9
3830B	NH-21	3830B (NH-21)	City of Los Angeles (Erwin WF)	10
3830N	NH-35	3830N (NH-35)	City of Los Angeles (Erwin WF)	10
3830P	NHE-7	3830P (NHE-7)	City of Los Angeles (Erwin WF)	10
3830Q		3830Q	Lockheed Aeronautics	10
3830R		3830R	Lockheed Aeronautics	10
3830S	3830S	3830S (3830S)	Lockheed Aeronautics	10
3831J	WH-6A	3831J (WH-6A)	City of Los Angeles (Whitnall WF)	11
3831K	NHE-8	3831K (NHE-8)	City of Los Angeles (Erwin WF)	11
3831Q		3831Q	Lockheed Aeronautics	11
3832K	WH-7	3832K (WH-7)	City of Los Angeles (Whitnall WF)	11
4886B	TJ-09	4886B (TJ-09)	LADWP	23
4886C	TJ-10	4886C (TJ-10)	LADWP	23
4886D	TJ-11	4886D (TJ-11)	LADWP	24
4886E	TJ-12	4886E (TJ-12)	LADWP	24
4887C	TJ-01	4887C (TJ-01)	LADWP	24
4887D	TJ-02	4887D (TJ-02)	LADWP	24
4887E	TJ-03	4887E (TJ-03)	LADWP	24
4887F	TJ-04	4887F (TJ-04)	LADWP	24
4887G	TJ-05	4887G (TJ-05)	LADWP	25
4887H	TJ-06	4887H (TJ-06)	LADWP	25
4887J	TJ-07	4887J (TJ-07)	LADWP	25
4887K	TJ-08	4887K (TJ-08)	LADWP	25
4898A	RT-2	4898A (RT-2)	City of Los Angeles (Rinaldi Toluca WF)	11
4898B	RT-3	4898B (RT-3)	City of Los Angeles (Rinaldi Toluca WF)	11
4898C	RT-4	4898C (RT-4)	City of Los Angeles (Rinaldi Toluca WF)	12
4898D	RT-5	4898D (RT-5)	City of Los Angeles (Rinaldi Toluca WF)	12
4898E	RT-6	4898E (RT-6)	City of Los Angeles (Rinaldi Toluca WF)	12

TABLE A-1

Pseudonyms of Selected Wells in North Hollywood Operable Unit

North Hollywood Operable Unit Chromium Evaluation

Primary Well Name in San Fernando Valley Database	Alternate Well Name in San Fernando Valley Database	Combined Well Name in San Fernando Valley Database	Well Owner Name in San Fernando Valley Database	Page
4898F	RT-7	4898F (RT-7)	City of Los Angeles (Rinaldi Toluca WF)	12
4898G	RT-8	4898G (RT-8)	City of Los Angeles (Rinaldi Toluca WF)	12
4898H	RT-9	4898H (RT-9)	City of Los Angeles (Rinaldi Toluca WF)	12
4909E	RT-1	4909E (RT-1)	City of Los Angeles (Rinaldi Toluca WF)	13
4909G	RT-10	4909G (RT-10)	City of Los Angeles (Rinaldi Toluca WF)	13
4909H	RT-12	4909H (RT-12)	City of Los Angeles (Rinaldi Toluca WF)	13
4909J	RT-13	4909J (RT-13)	City of Los Angeles (Rinaldi Toluca WF)	13
4909K	RT-11	4909K (RT-11)	City of Los Angeles (Rinaldi Toluca WF)	13
4909L	RT-14	4909L (RT-14)	City of Los Angeles (Rinaldi Toluca WF)	13
4909M	RT-15	4909M (RT-15)	City of Los Angeles (Rinaldi Toluca WF)	14
4948		4948	Lockheed Aeronautics	1
LA1-CW04	A1-CW04	LA1-CW04 (A1-CW04)	Lockheed Aeronautics	1
LB5-CW01		LB5-CW01	Lockheed Aeronautics	1
LB5-CW02		LB5-CW02	Lockheed Aeronautics	1
LB5-CW03		LB5-CW03	Lockheed Aeronautics	1
LB6-CW07		LB6-CW07	Lockheed Aeronautics	1
LB6-CW08		LB6-CW08	Lockheed Aeronautics	2
LB6-CW09		LB6-CW09	Lockheed Aeronautics	2
LB6-CW10		LB6-CW10	Lockheed Aeronautics	2
LB6-CW17		LB6-CW17	Lockheed Aeronautics	2
LB6-MW01		LB6-MW01	Lockheed Aeronautics	2
LC1-CW01		LC1-CW01	Lockheed Aeronautics	14
LC1-CW02	C1-CW02	LC1-CW02 (C1-CW02)	Lockheed Aeronautics	14
LC1-CW03	C1-CW03	LC1-CW03 (C1-CW03)	Lockheed Aeronautics	14
LC1-CW04		LC1-CW04	Lockheed Aeronautics	2
LC1-CW05		LC1-CW05	Lockheed Aeronautics	3
LC1-CW06	C1-CW06	LC1-CW06 (C1-CW06)	Lockheed Aeronautics	3
LC1-CW07		LC1-CW07	Lockheed Aeronautics	3
LC1-CW08		LC1-CW08	Lockheed Aeronautics	3
LC1-MW01		LC1-MW01	Lockheed Aeronautics	3
NH-C01-325	NH-C01-325	NH-C01-325 (NH-C01-325)	EPA	14
NH-C01-450	NH-C01-450	NH-C01-450 (NH-C01-450)	EPA	14
NH-C01-660	NH-C01-660	NH-C01-660 (NH-C01-660)	EPA	15
NH-C01-780	NH-C01-780	NH-C01-780 (NH-C01-780)	EPA	15
NH-C02-220	NH-C02-220	NH-C02-220 (NH-C02-220)	EPA	15
NH-C02-325	NH-C02-325	NH-C02-325 (NH-C02-325)	EPA	15
NH-C02-520	NH-C02-520	NH-C02-520 (NH-C02-520)	EPA	15

TABLE A-1

Pseudonyms of Selected Wells in North Hollywood Operable Unit
North Hollywood Operable Unit Chromium Evaluation

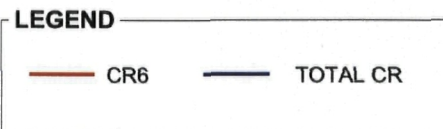
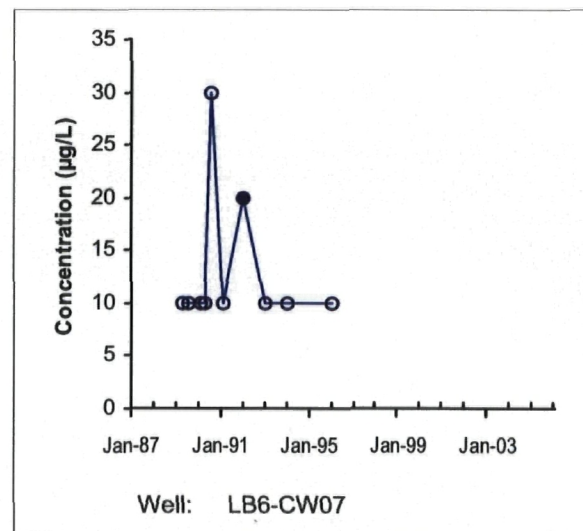
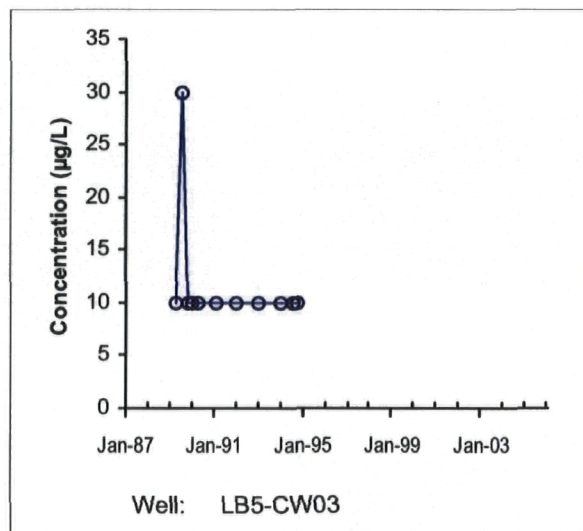
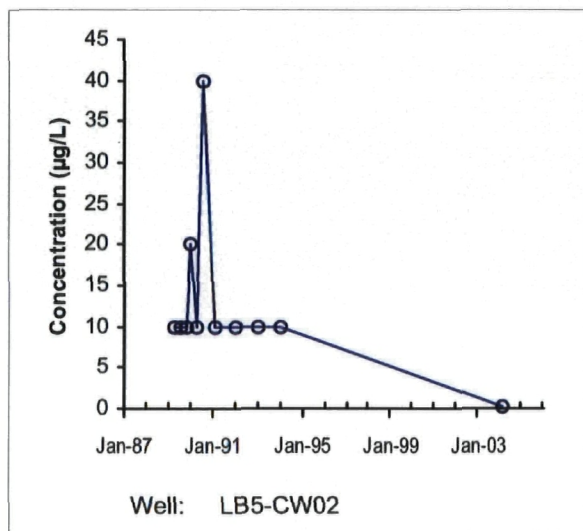
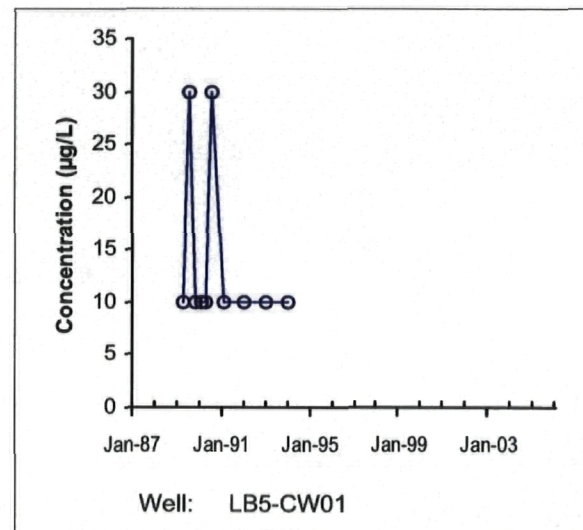
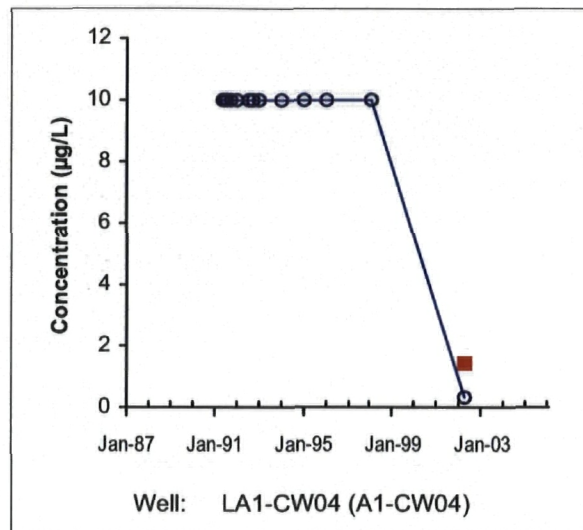
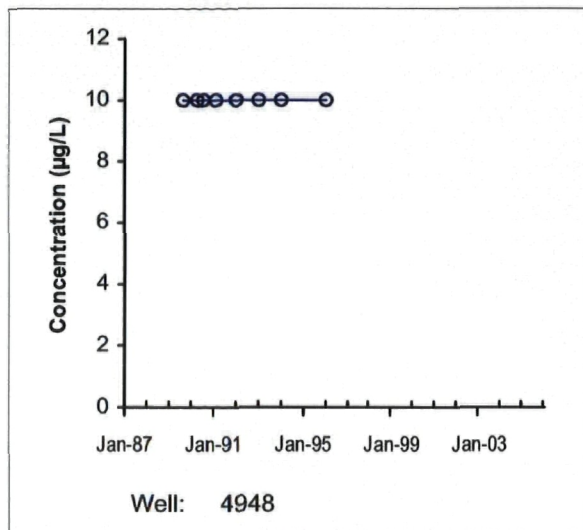
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NH-C02-681	NH-C02-681	NH-C02-681 (NH-C02-681)	EPA	15
NH-C03-380	NH-C03-380	NH-C03-380 (NH-C03-380)	EPA	16
NH-C03-580	NH-C03-580	NH-C03-580 (NH-C03-580)	EPA	16
NH-C03-680	NH-C03-680	NH-C03-680 (NH-C03-680)	EPA	16
NH-C03-800	NH-C03-800	NH-C03-800 (NH-C03-800)	EPA	16
NH-C05-320	NH-C05-320	NH-C05-320 (NH-C05-320)	EPA	16
NH-C05-460	NH-C05-460	NH-C05-460 (NH-C05-460)	EPA	16
NH-C06-160	NH-C06-160	NH-C06-160 (NH-C06-160)	EPA	5
NH-C06-285	NH-C06-285	NH-C06-285 (NH-C06-285)	EPA	5
NH-C06-425	NH-C06-425	NH-C06-425 (NH-C06-425)	EPA	5
NH-VPB-02	NH-VPB-02	NH-VPB-02 (NH-VPB-02)	EPA	17
NH-VPB-03	NH-VPB-03	NH-VPB-03 (NH-VPB-03)	EPA	17
NH-VPB-04	NH-VPB-04	NH-VPB-04 (NH-VPB-04)	EPA	17
NH-VPB-05	NH-VPB-05	NH-VPB-05 (NH-VPB-05)	EPA	3
NH-VPB-06	NH-VPB-06	NH-VPB-06 (NH-VPB-06)	EPA	17
NH-VPB-07	NH-VPB-07	NH-VPB-07 (NH-VPB-07)	EPA	17
NH-VPB-08	NH-VPB-08	NH-VPB-08 (NH-VPB-08)	EPA	17
NH-VPB-09	NH-VPB-09	NH-VPB-09 (NH-VPB-09)	EPA	18
NH-VPB-10	NH-VPB-10	NH-VPB-10 (NH-VPB-10)	EPA	4
NH-VPB-11	NH-VPB-11	NH-VPB-11 (NH-VPB-11)	EPA	18
NH-VPB-13		NH-VPB-13	EPA	25
V13ALS10	BX1-W10	V13ALS10 (BX1-W10)	Allied Signal-Bendix (Home Depot) (Honeywell)	18
V13ALSW1	BX1-W1	V13ALSW1 (BX1-W1)	Allied Signal-Bendix (Home Depot) (Honeywell)	18
V13ALSW2	BX1-W2	V13ALSW2 (BX1-W2)	Allied Signal-Bendix (Home Depot) (Honeywell)	18
V13ALSW3	BX1-W3	V13ALSW3 (BX1-W3)	Allied Signal-Bendix (Home Depot) (Honeywell)	18
V13ALSW4	BX1-W4	V13ALSW4 (BX1-W4)	Allied Signal-Bendix (Home Depot) (Honeywell)	19
V13ALSW5	BX1-W5	V13ALSW5 (BX1-W5)	Allied Signal-Bendix (Home Depot) (Honeywell)	19
V13ALSW6	BX1-W6	V13ALSW6 (BX1-W6)	Allied Signal-Bendix (Home Depot) (Honeywell)	19
V13ALSW7	BX1-W7	V13ALSW7 (BX1-W7)	Allied Signal-Bendix (Home Depot) (Honeywell)	19
V13ALSW8	BX1-W8	V13ALSW8 (BX1-W8)	Allied Signal-Bendix (Home Depot) (Honeywell)	19
V13ALSW9	BX1-W9	V13ALSW9 (BX1-W9)	Allied Signal-Bendix (Home Depot) (Honeywell)	19

TABLE A-1

Pseudonyms of Selected Wells in North Hollywood Operable Unit

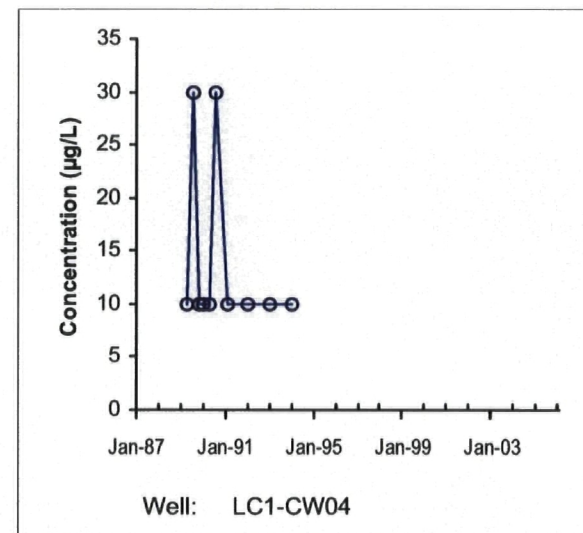
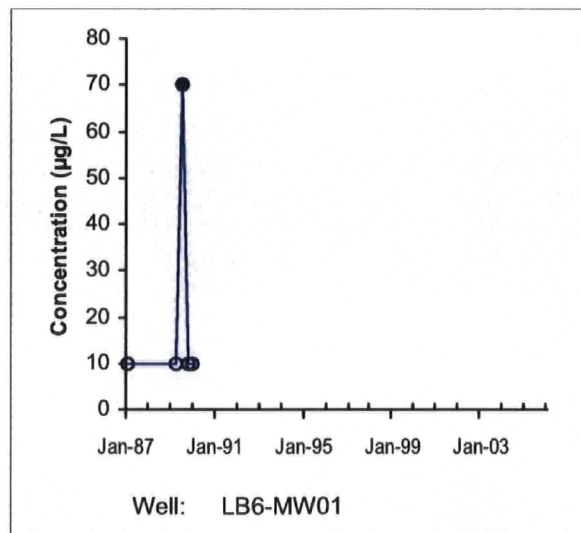
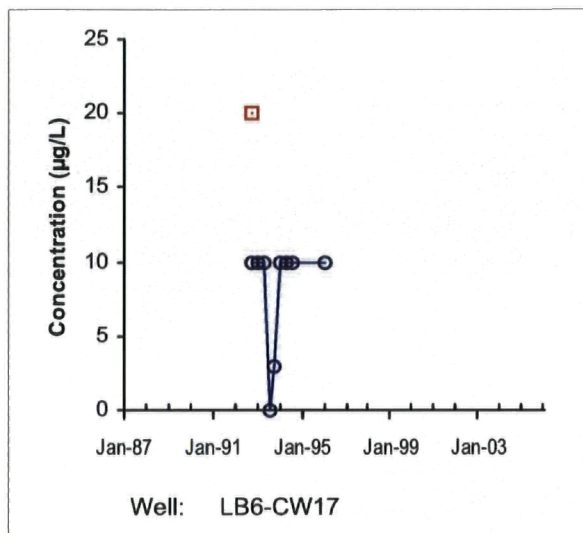
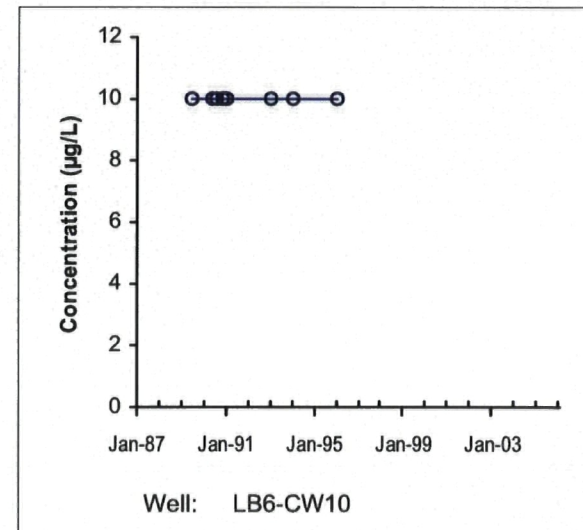
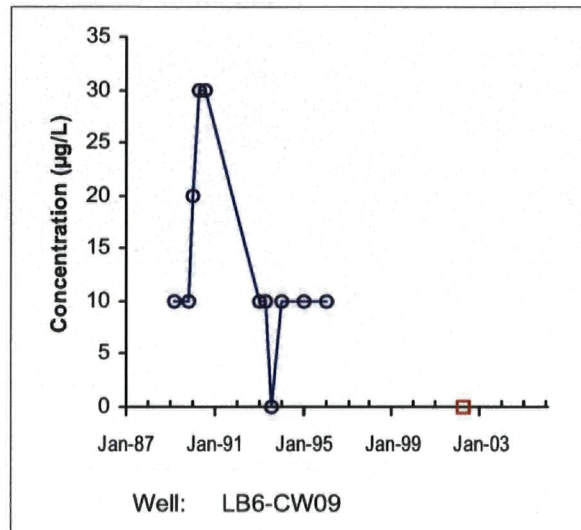
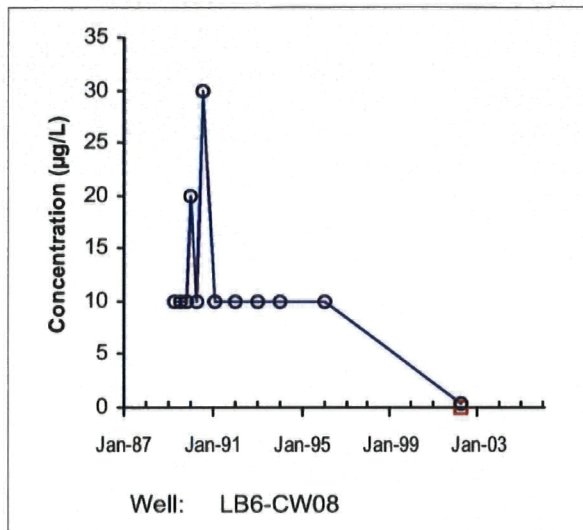
North Hollywood Operable Unit Chromium Evaluation

Primary Well Name in San Fernando Valley Database	Alternate Well Name in San Fernando Valley Database	Combined Well Name in San Fernando Valley Database	Well Owner Name in San Fernando Valley Database	Page
V14107B8	4918B	V14107B8 (4918B)	Penrose Landfill	20
V14107D8	4918A	V14107D8 (4918A)	Penrose Landfill	20
V14107P8	4918	V14107P8 (4918)	Penrose Landfill	20
V14705A8	4928A	V14705A8 (4928A)	Strathem Pit	20
V14713B8	4928B	V14713B8 (4928B)	Newberry Landfill	20
V14713C8	4928C	V14713C8 (4928C)	Newberry Landfill	20
V14713W7	4927	V14713W7 (4927)	Newberry Landfill	21
V1471406	4916	V1471406 (4916)	Bradley Landfill & Recycling	25
V14714A6	4916A	V14714A6 (4916A)	Bradley Landfill & Recycling	26
V14714C6	4916C	V14714C6 (4916C)	Bradley Landfill & Recycling	26
V14714D6	4916D	V14714D6 (4916D)	Bradley Landfill & Recycling	26
V14714F6	4916F	V14714F6 (4916F)	Bradley Landfill & Recycling	26
V14714H6	4916H	V14714H6 (4916H)	Bradley Landfill & Recycling	26
V14714J6	4916J	V14714J6 (4916J)	Bradley Landfill & Recycling	26
V14714L6	4916L	V14714L6 (4916L)	Bradley Landfill & Recycling	27
V14GP26B	4926B	V14GP26B (4926B)	Greg Pit	27
V14HEW99	4899	V14HEW99 (4899)	Hewitt Landfill	21
V14HEW9F	4909F	V14HEW9F (4909F)	Hewitt Landfill	21
V14HEWC9	4909C	V14HEWC9 (4909C)	Hewitt Landfill	21
V14SA97A	4897A	V14SA97A (4897A)	Sheldon-Arleta Sanitary	27
V14SA97J	4897	V14SA97J (4897)	Sheldon-Arleta Sanitary	21
V14SA98M	4898	V14SA98M (4898)	Sheldon-Arleta Sanitary	21
V14SASA1	SA-1	V14SASA1 (SA-1)	Sheldon-Arleta Sanitary	27
V14SASA2	SA-2	V14SASA2 (SA-2)	Sheldon-Arleta Sanitary	27
V14SASA3	SA-3	V14SASA3 (SA-3)	Sheldon-Arleta Sanitary	27
V14SASA5	SA-5	V14SASA5 (SA-5)	Sheldon-Arleta Sanitary	28
V14TUX06	4917A	V14TUX06 (4917A)	Tuxford Landfill	22
V14TUX07	4917B	V14TUX07 (4917B)	Tuxford Landfill	22



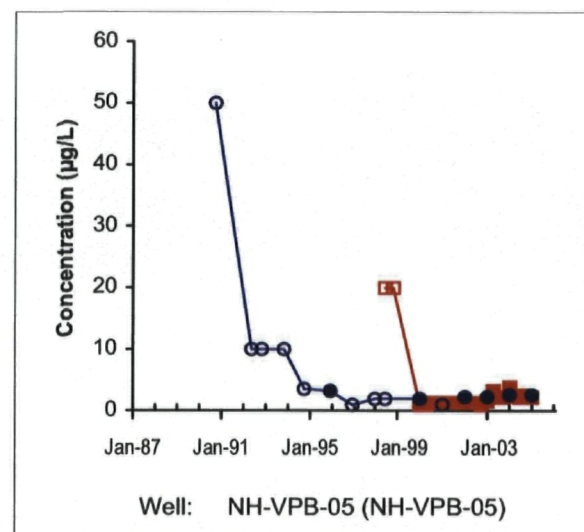
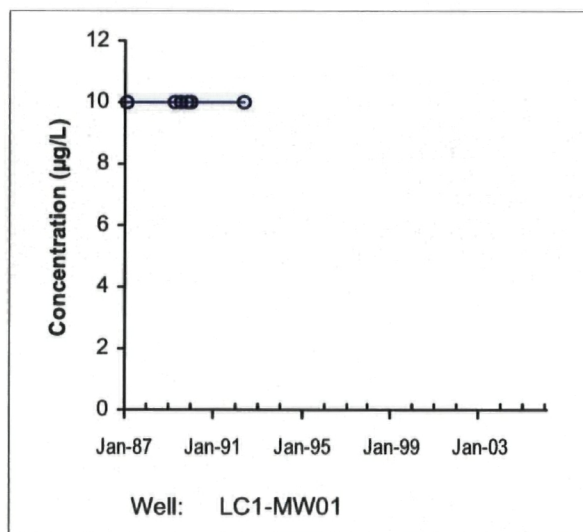
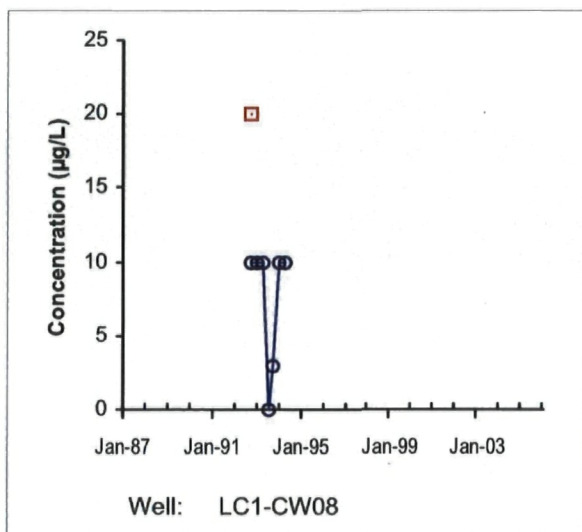
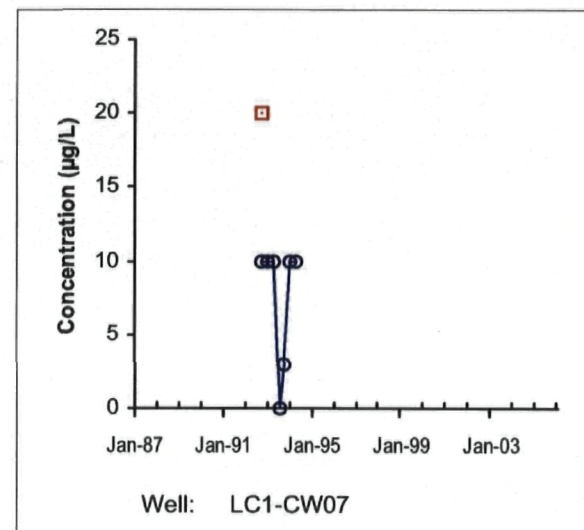
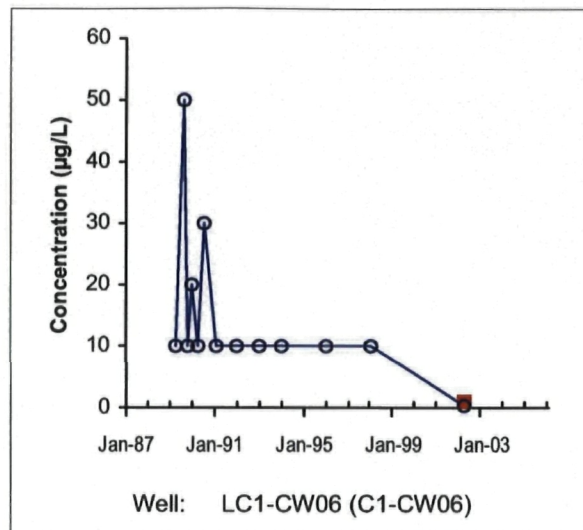
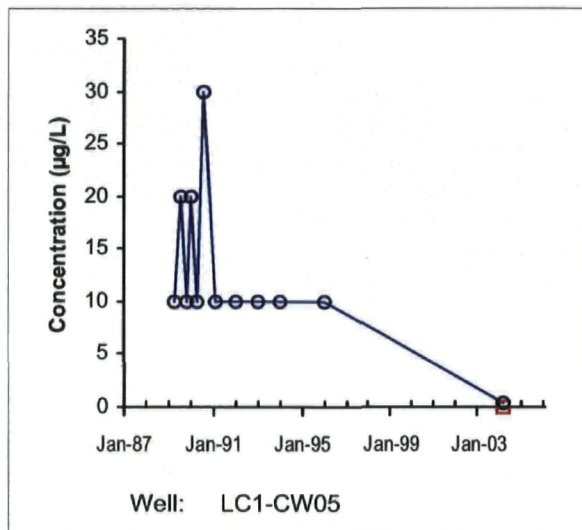
Chromium Time Series Plots BURBANK

* Nondetects shown at MDL with open symbols



* Nondetects shown at MDL with open symbols

Chromium Time Series Plots BURBANK

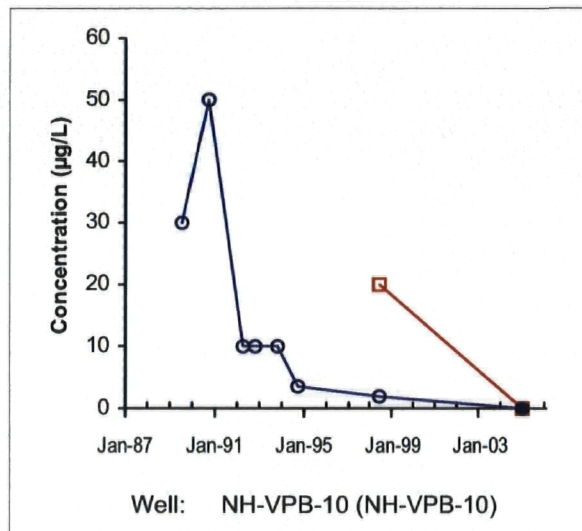


LEGEND

— CR6 — TOTAL CR

* Nondetects shown at MDL with open symbols

Chromium Time Series Plots BURBANK

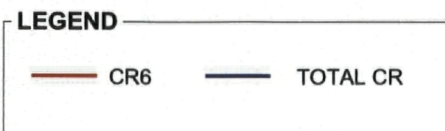
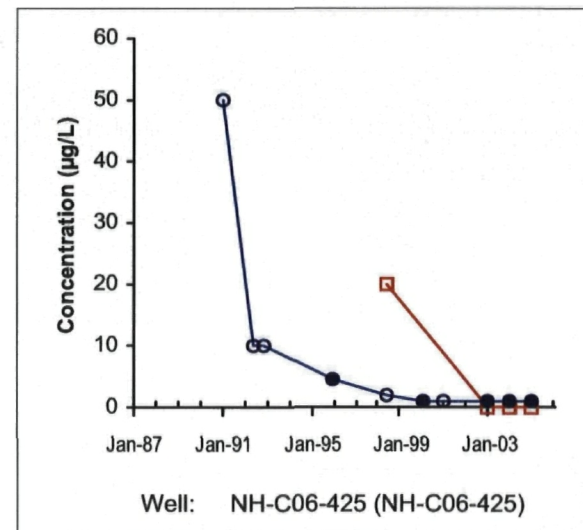
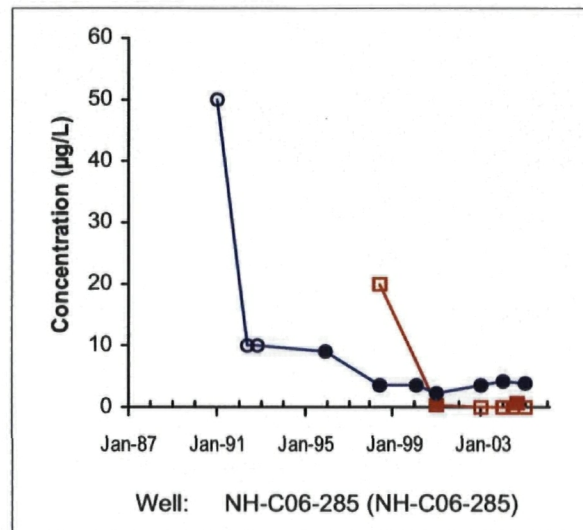
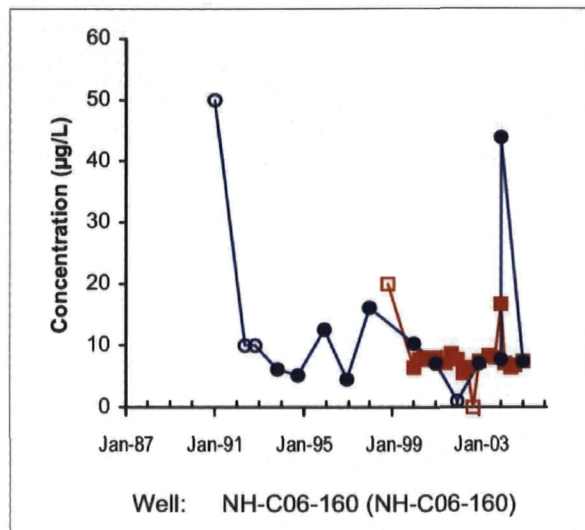


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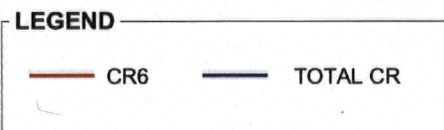
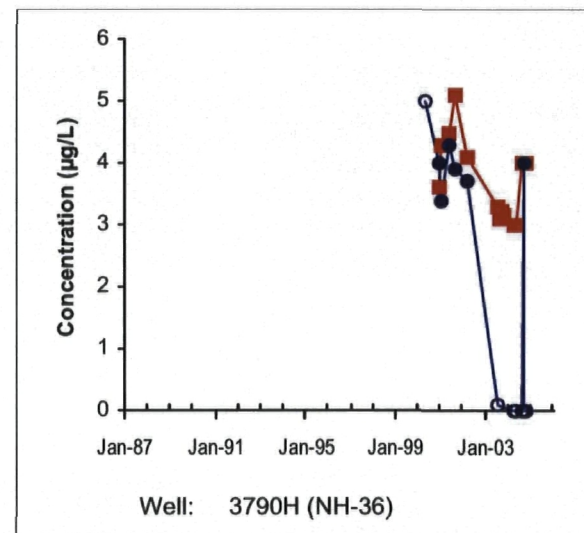
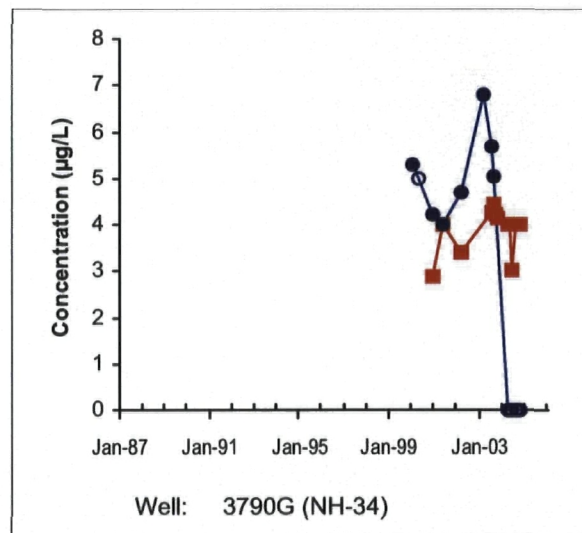
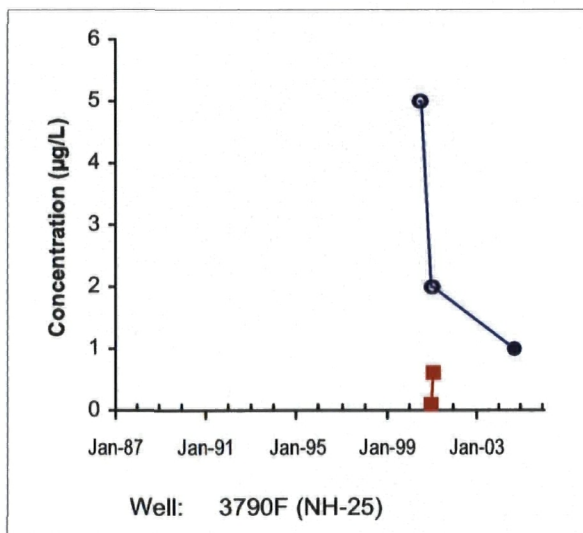
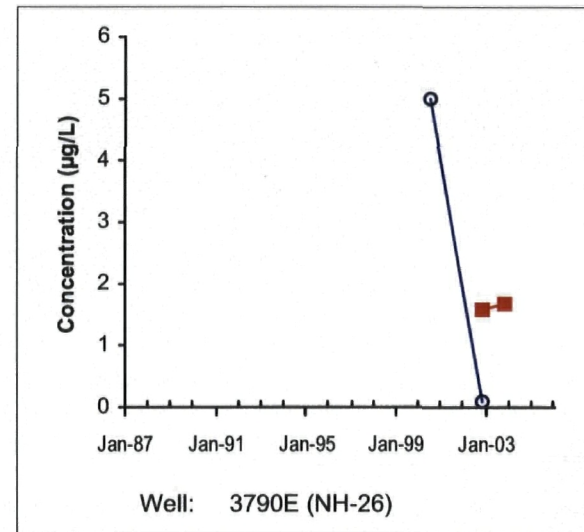
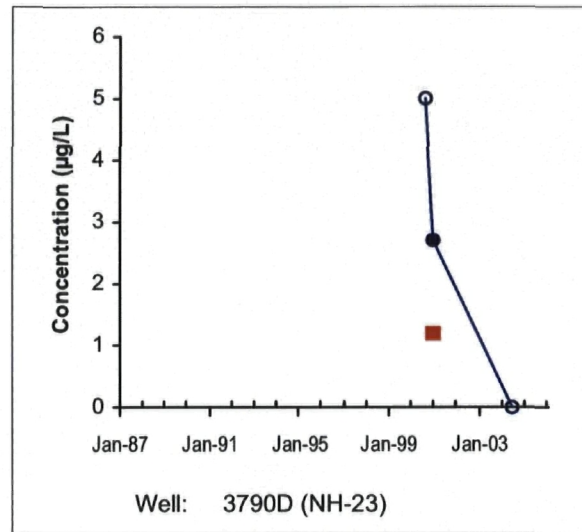
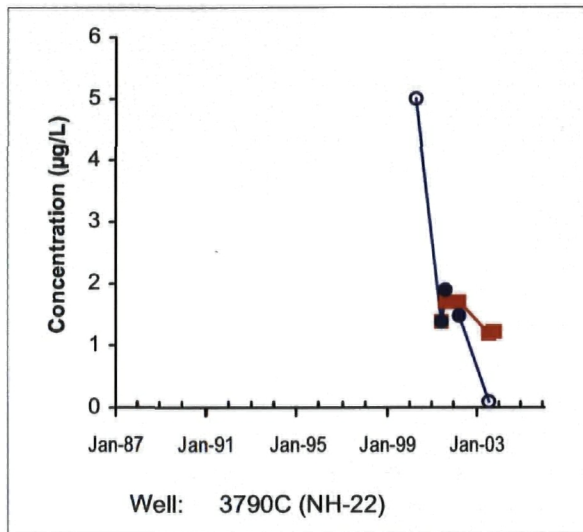
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**Chromium Time Series Plots
BURBANK**



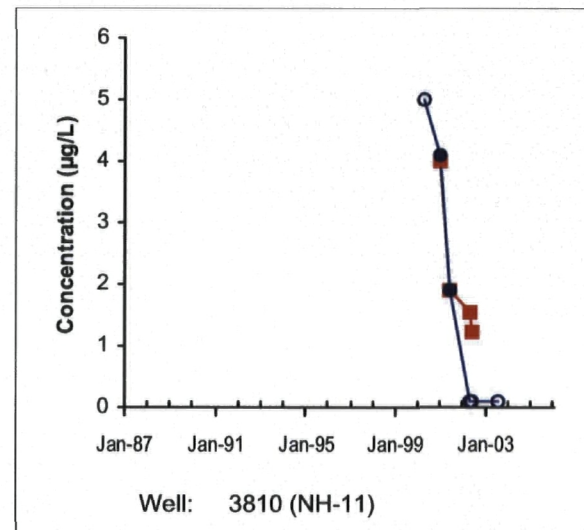
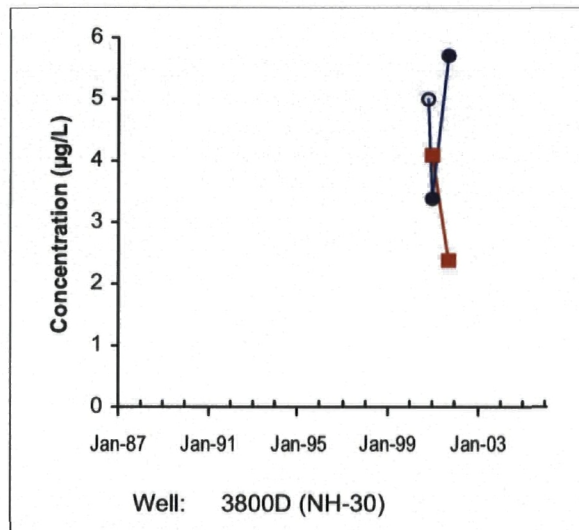
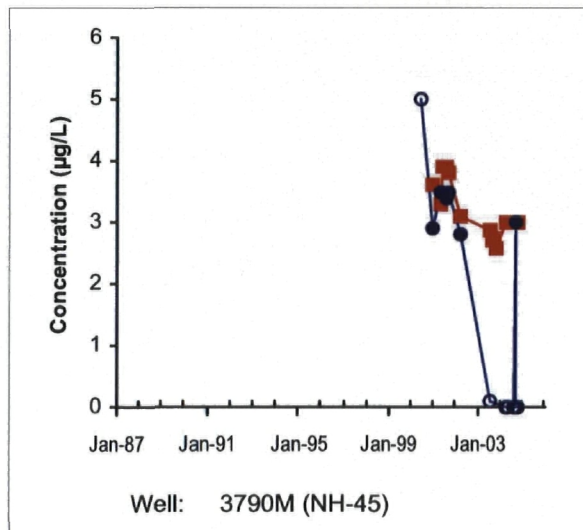
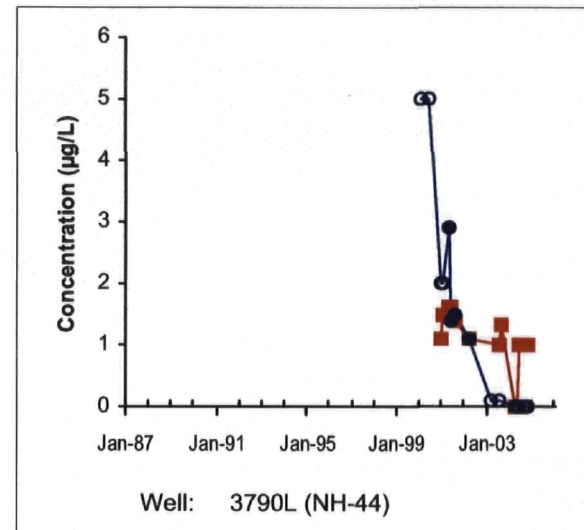
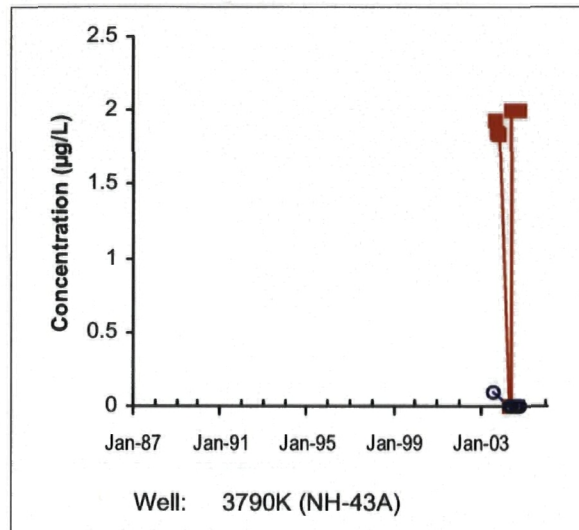
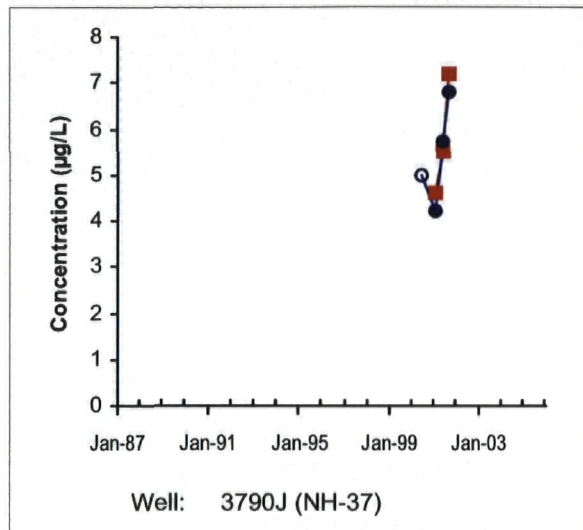
* Nondetects shown at MDL with open symbols

Chromium Time Series Plots GLENDALE NORTH



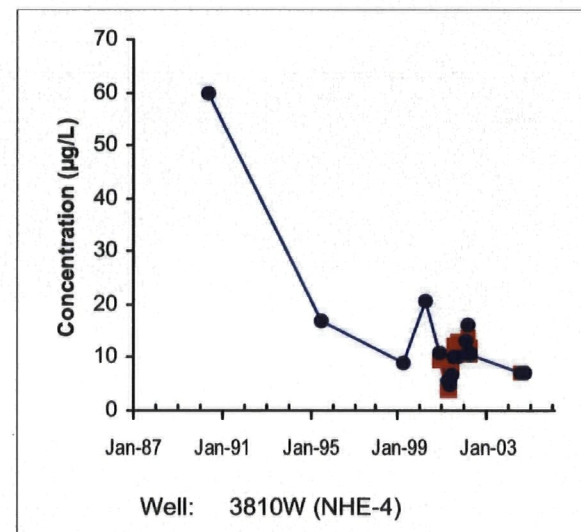
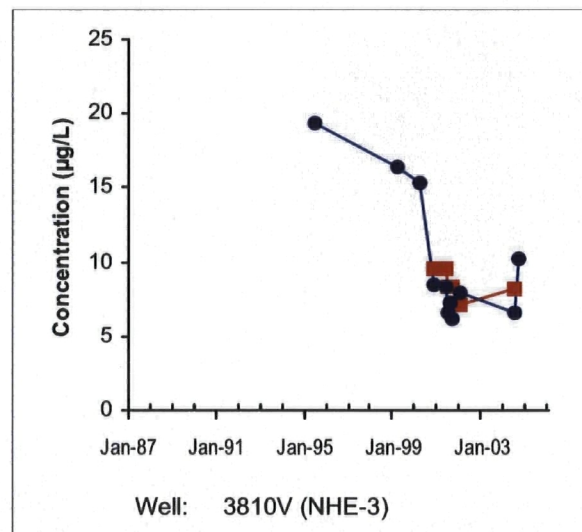
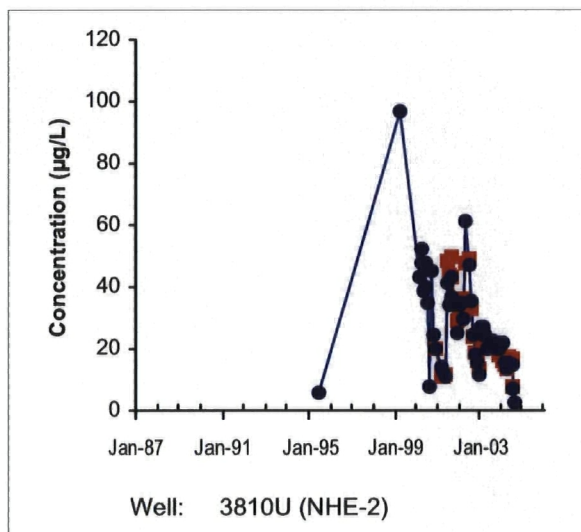
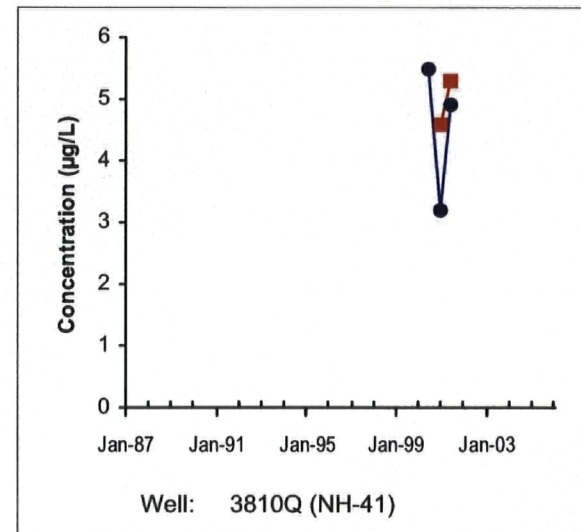
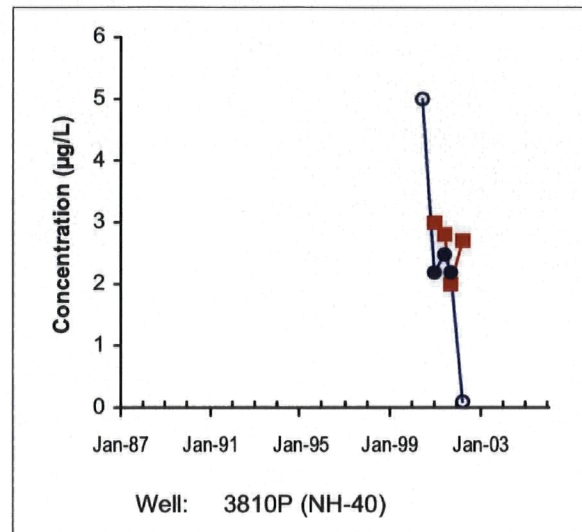
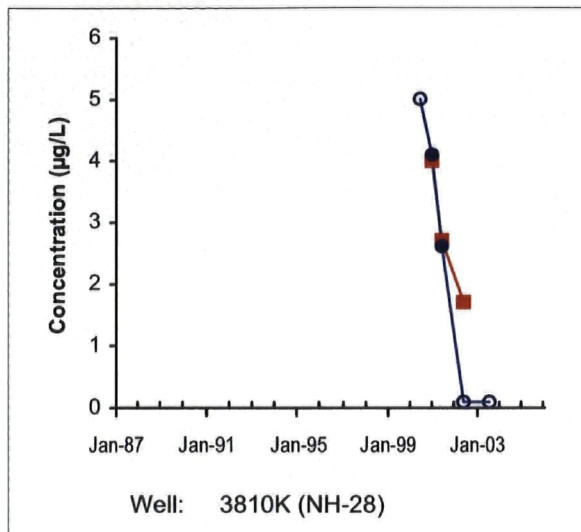
* Nondetects shown at MDL with open symbols

Chromium Time Series Plots NORTH HOLLYWOOD



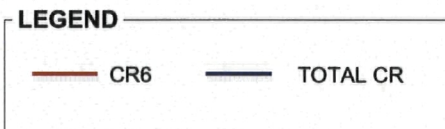
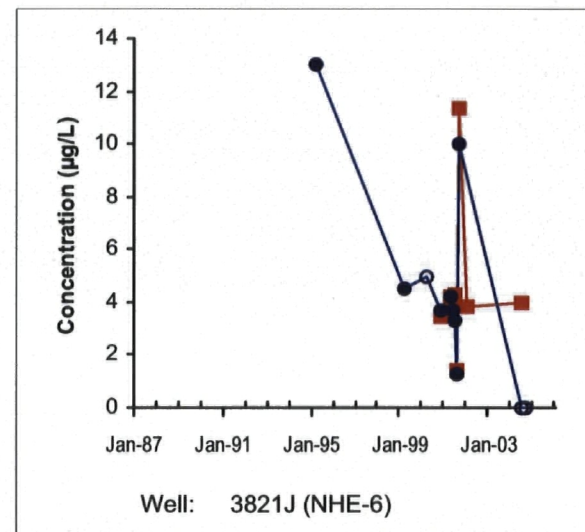
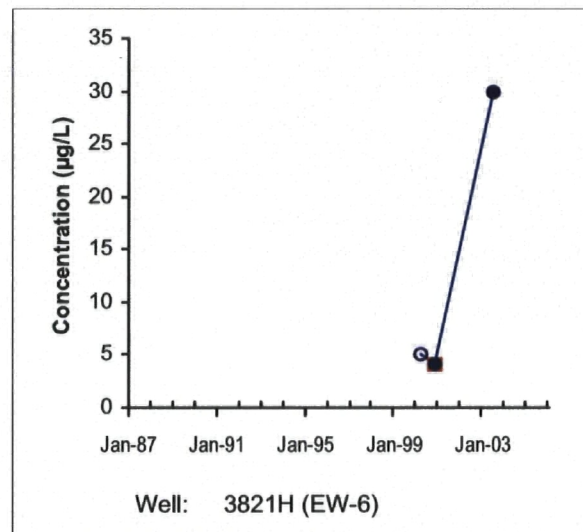
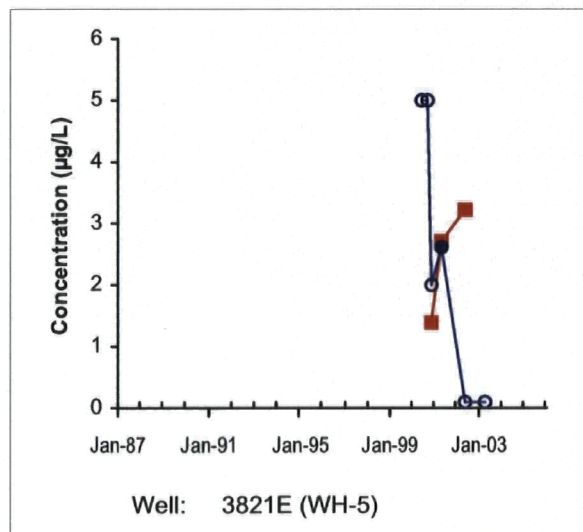
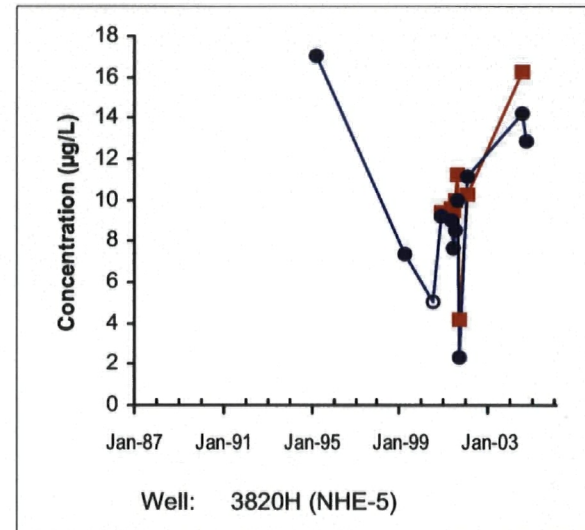
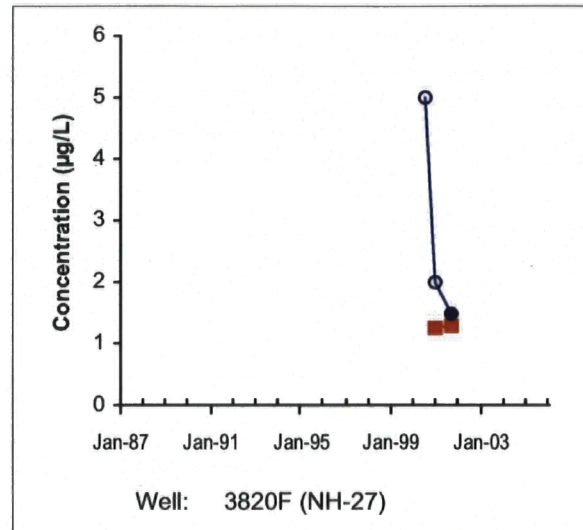
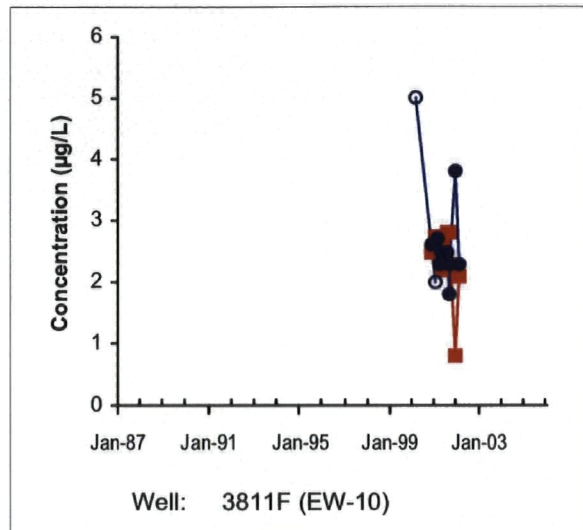
* Nondetects shown at MDL with open symbols

Chromium Time Series Plots NORTH HOLLYWOOD



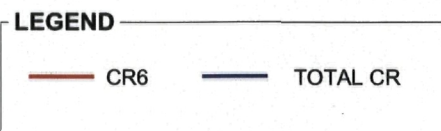
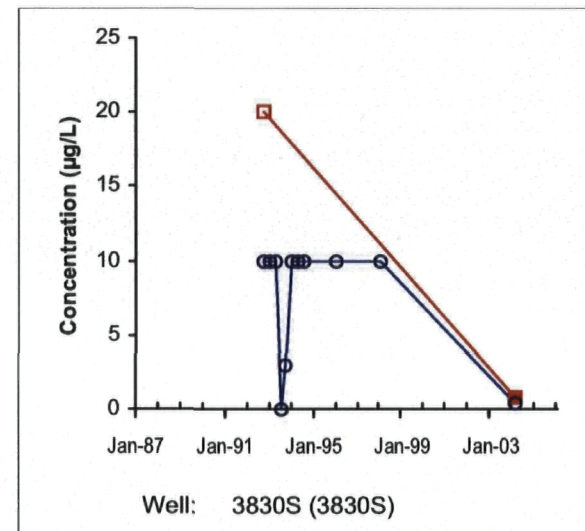
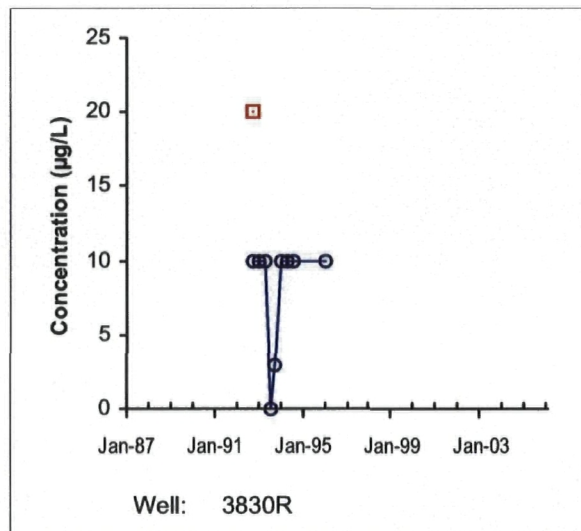
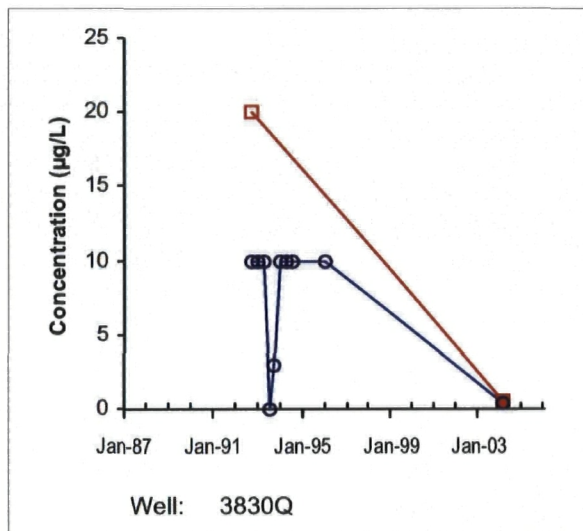
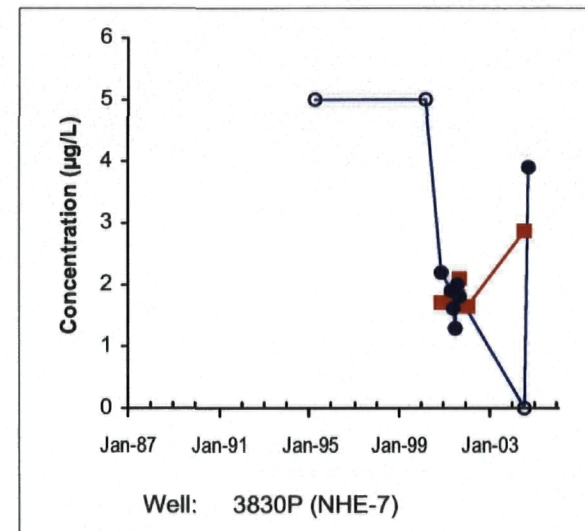
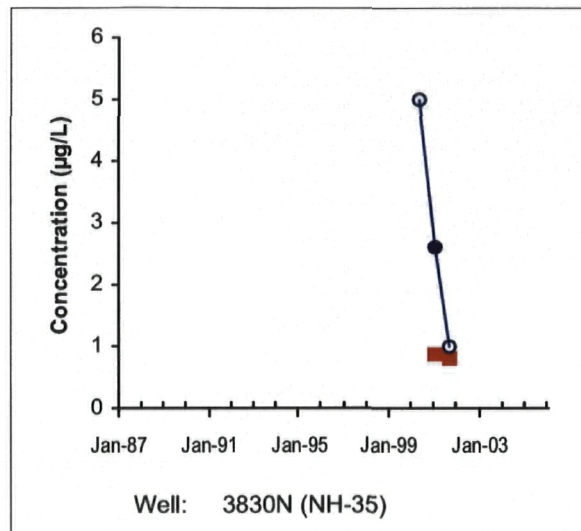
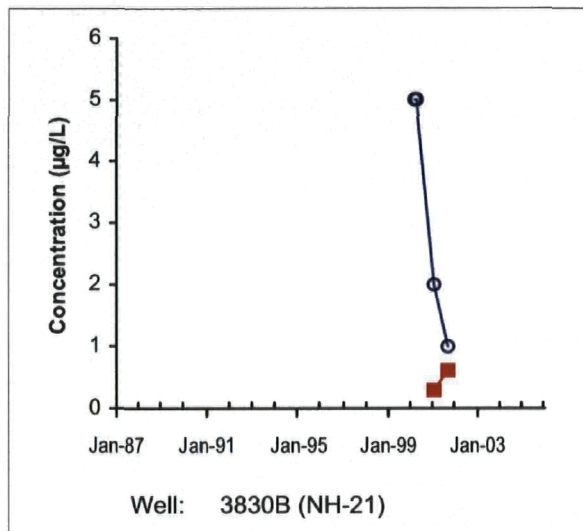
* Nondetects shown at MDL with open symbols

Chromium Time Series Plots NORTH HOLLYWOOD



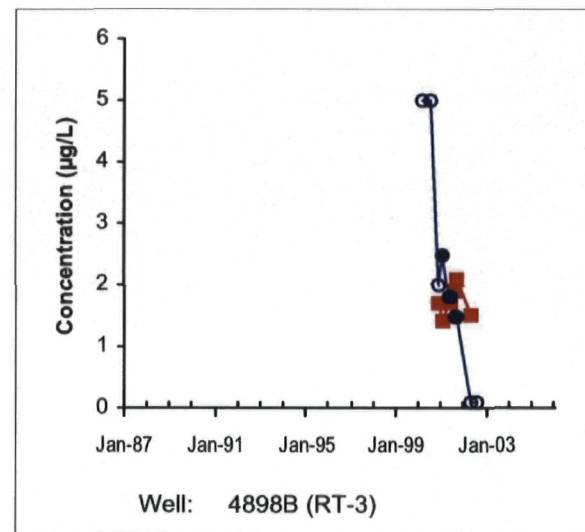
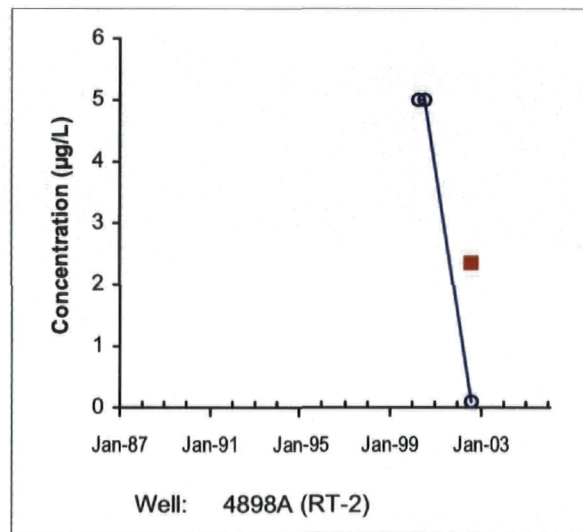
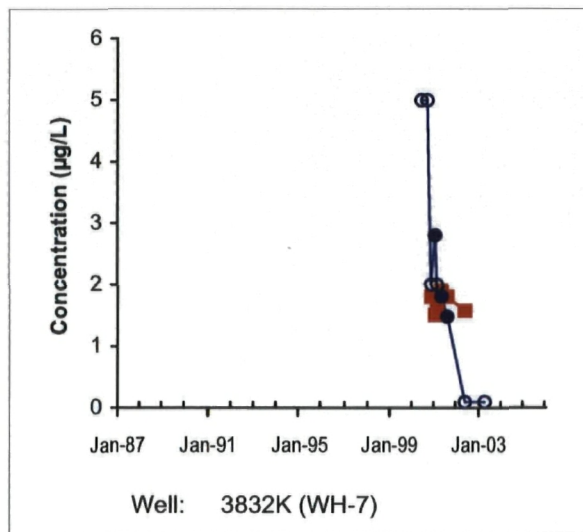
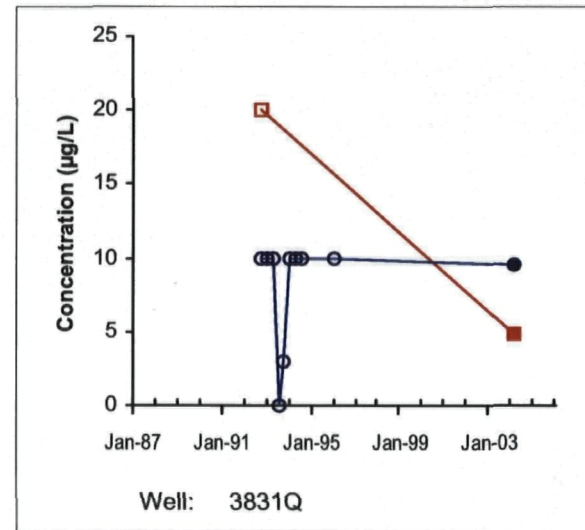
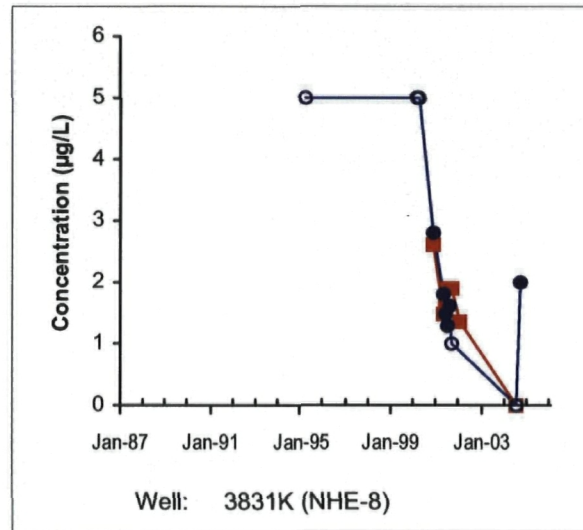
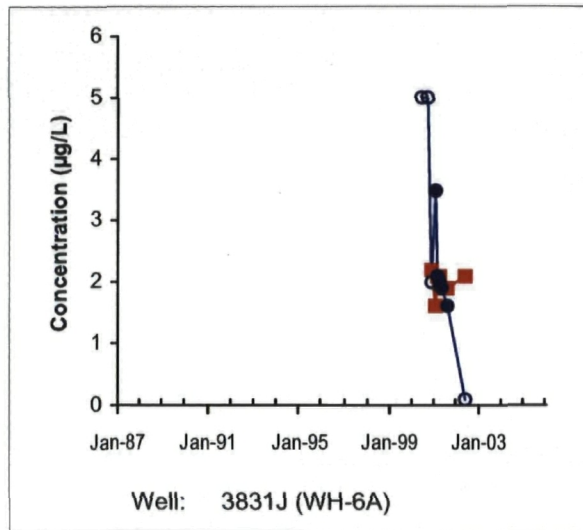
* Nondetects shown at MDL with open symbols

Chromium Time Series Plots NORTH HOLLYWOOD



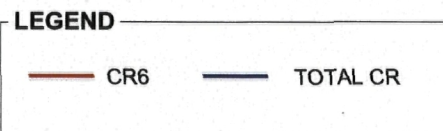
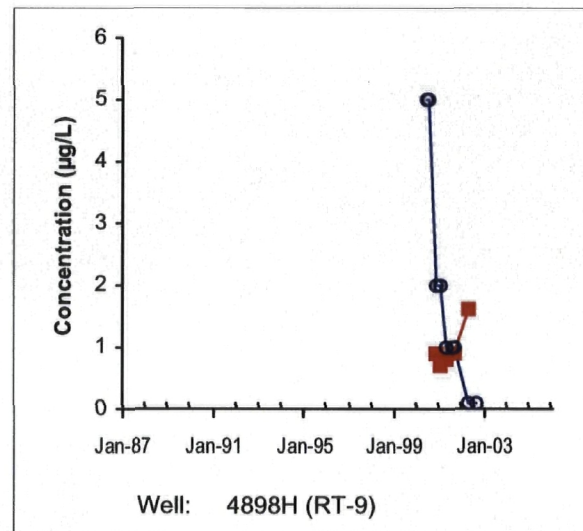
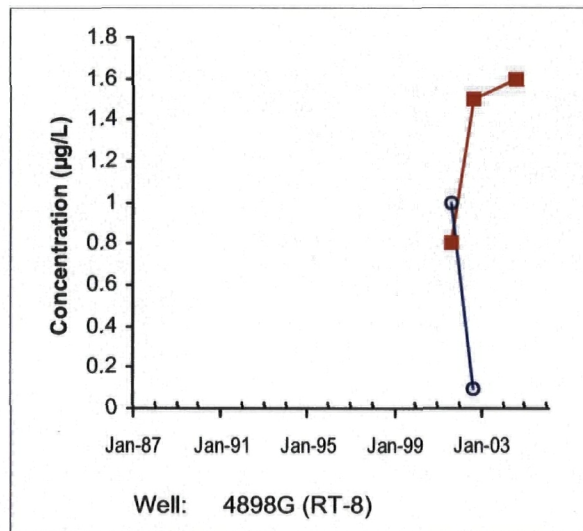
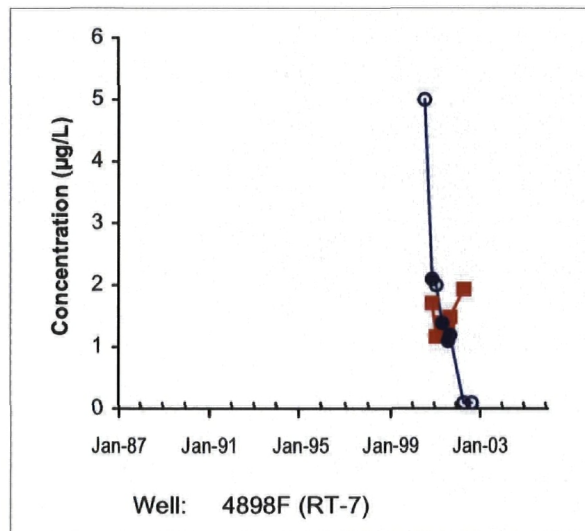
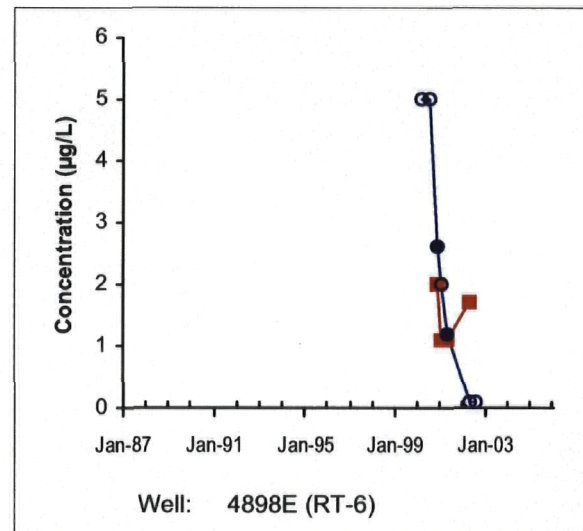
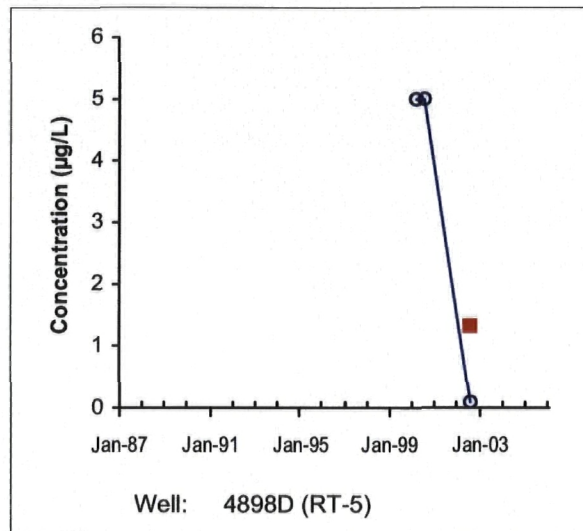
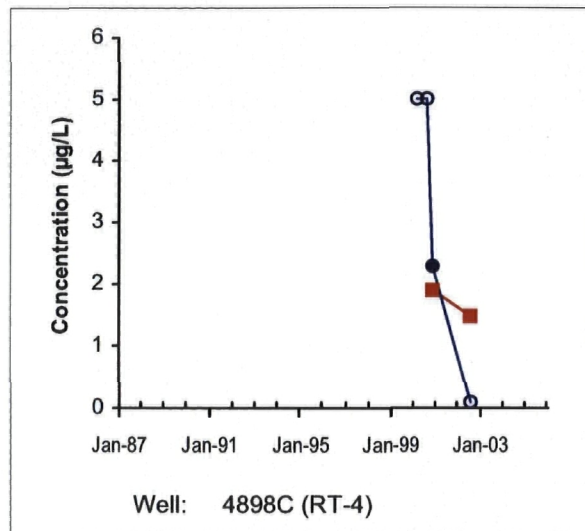
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Chromium Time Series Plots NORTH HOLLYWOOD



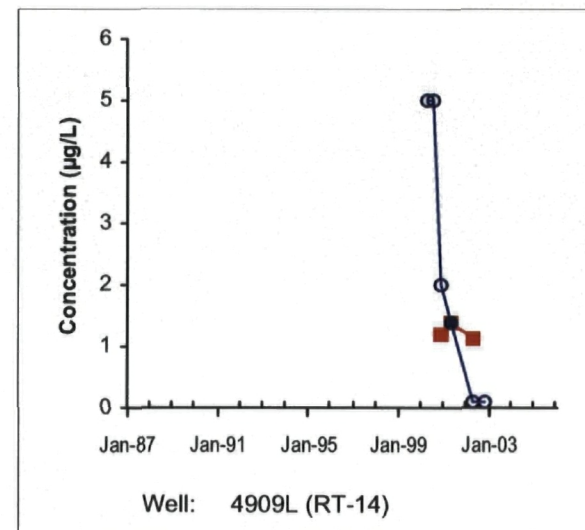
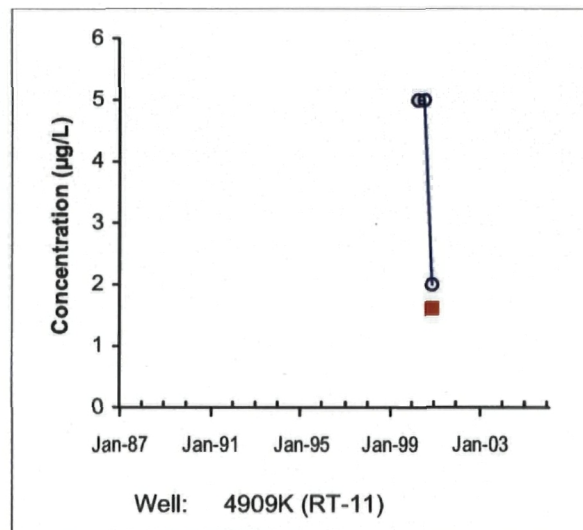
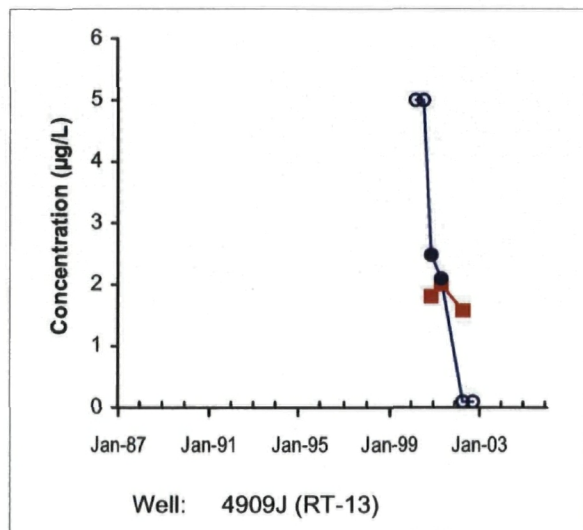
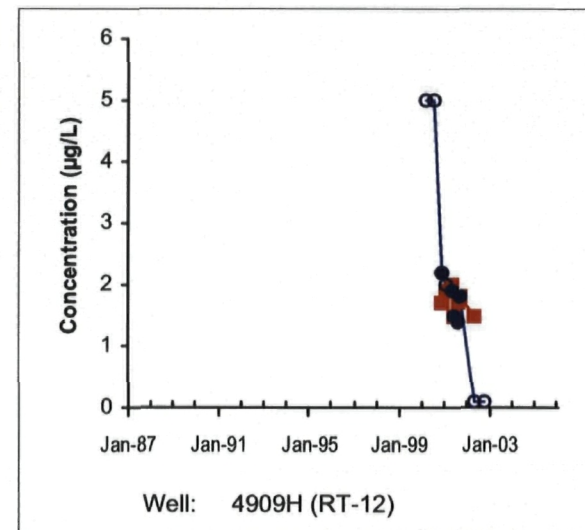
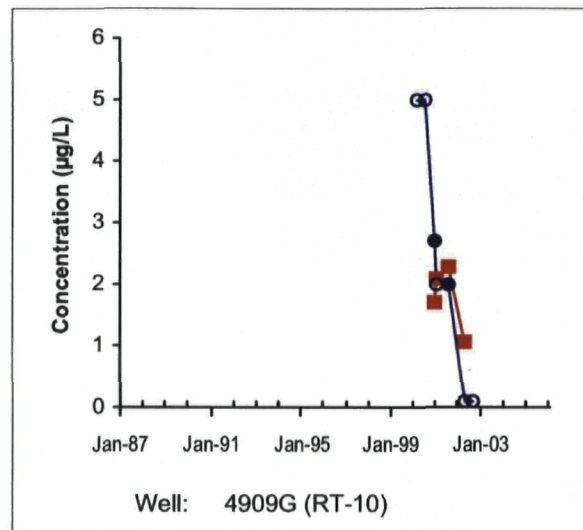
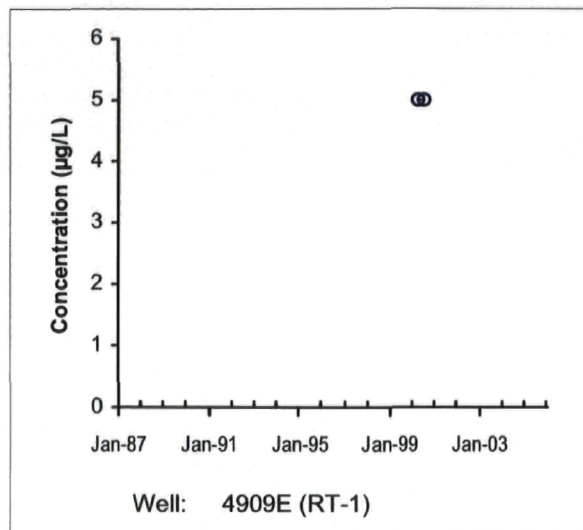
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Chromium Time Series Plots NORTH HOLLYWOOD



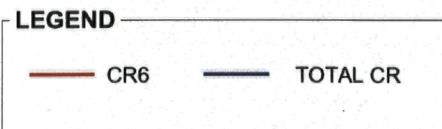
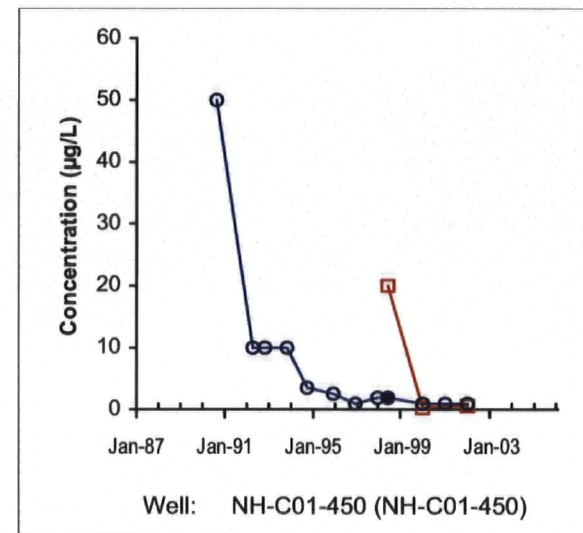
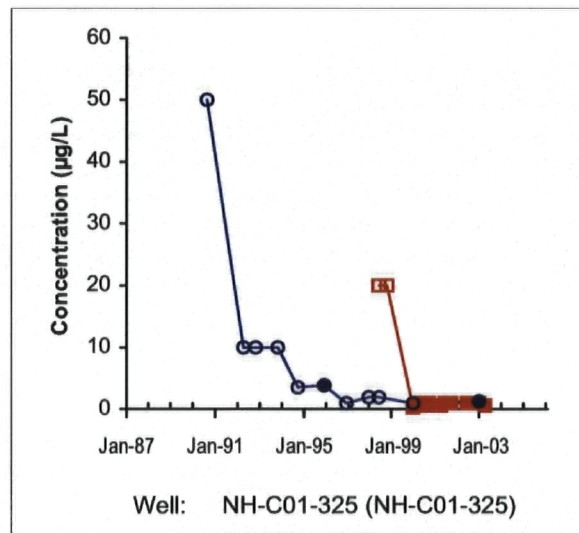
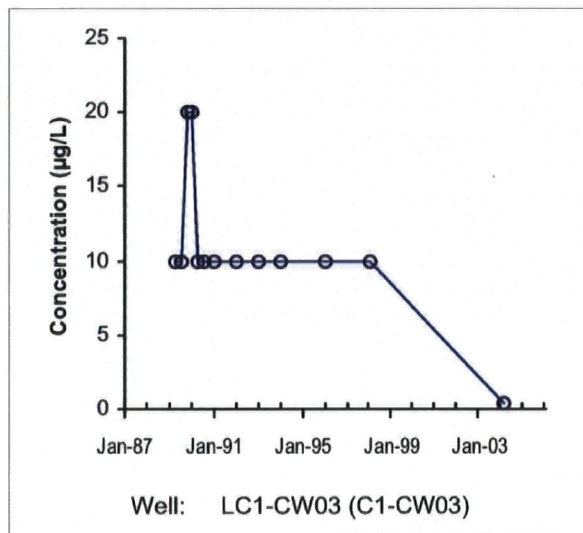
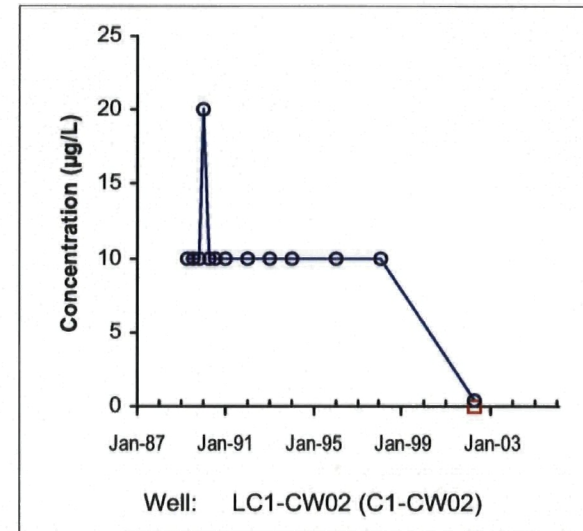
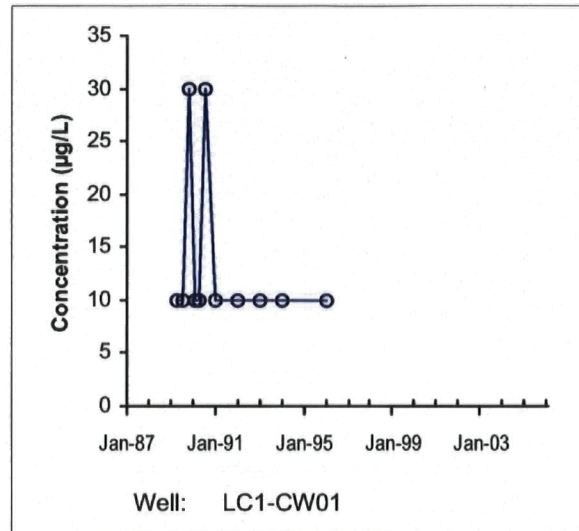
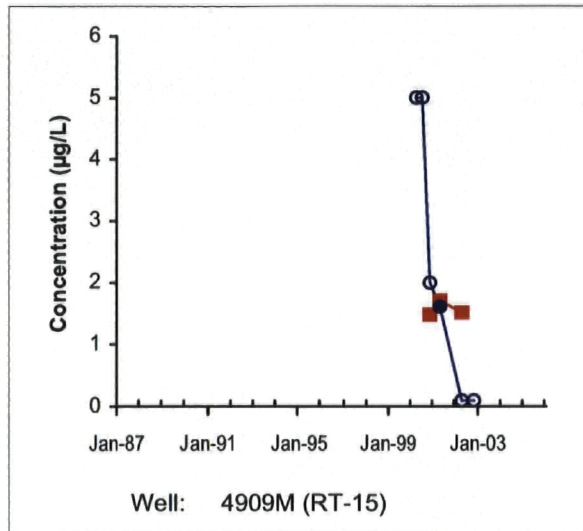
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Chromium Time Series Plots NORTH HOLLYWOOD



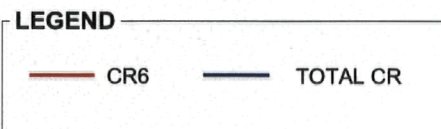
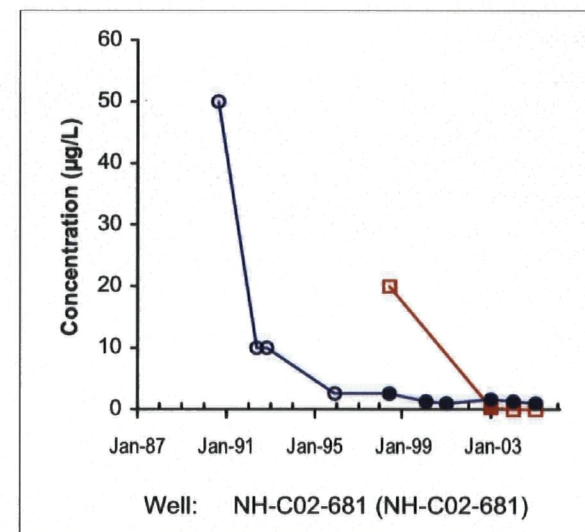
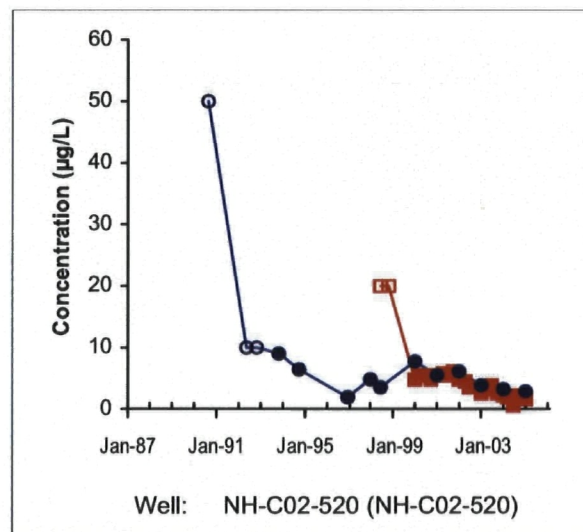
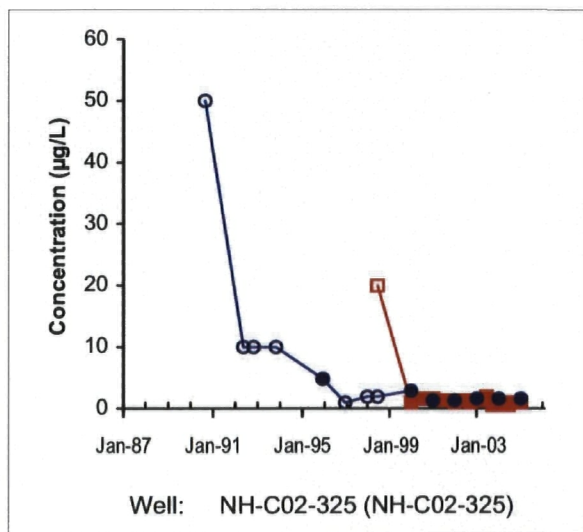
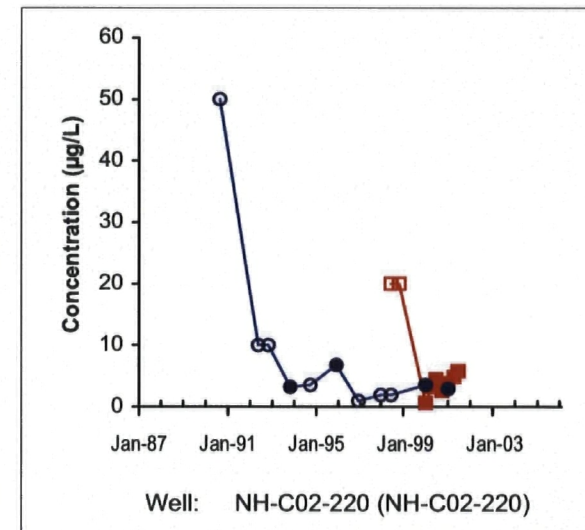
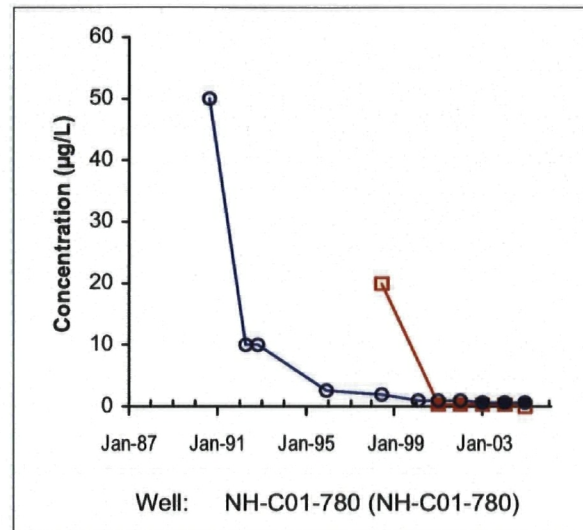
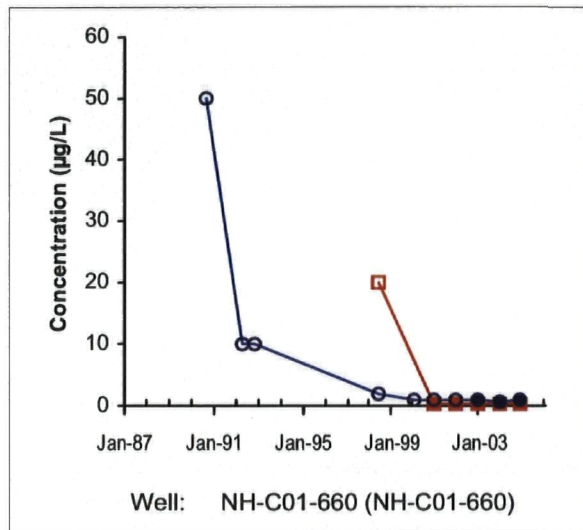
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Chromium Time Series Plots NORTH HOLLYWOOD



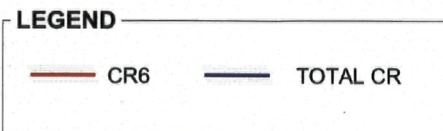
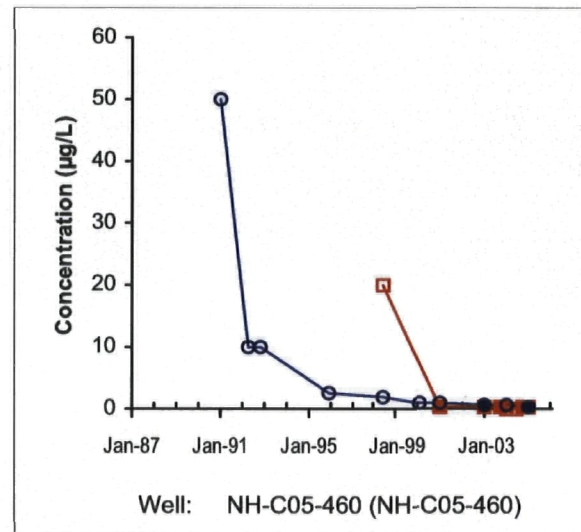
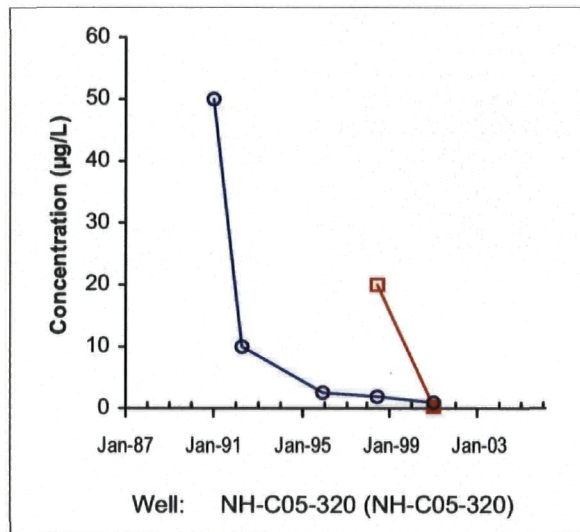
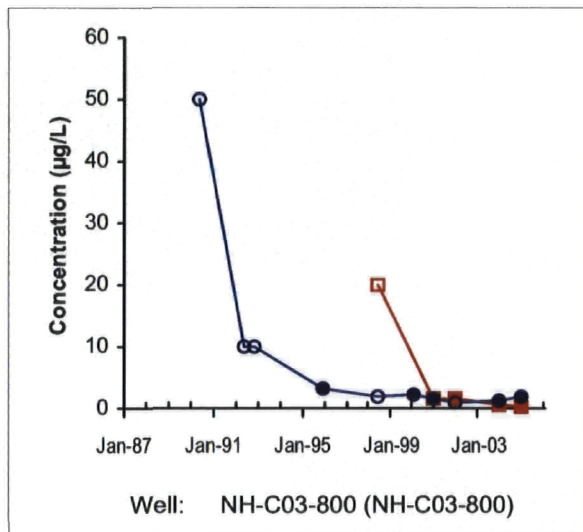
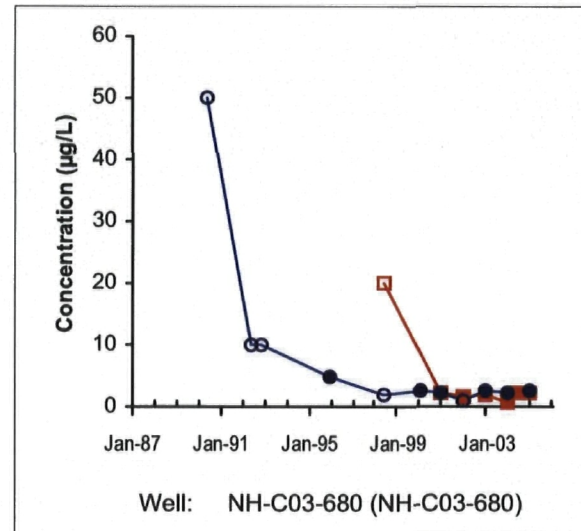
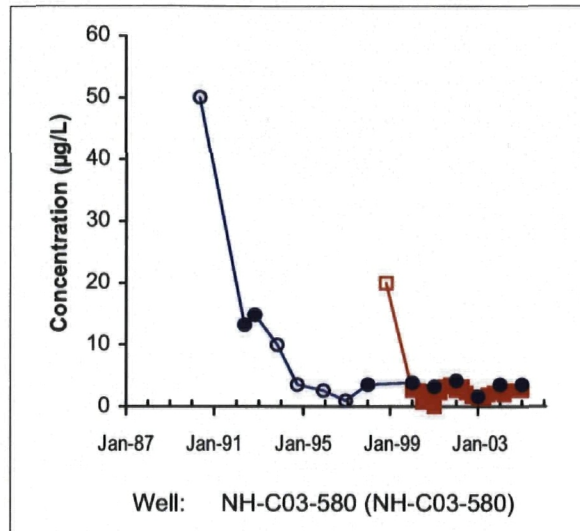
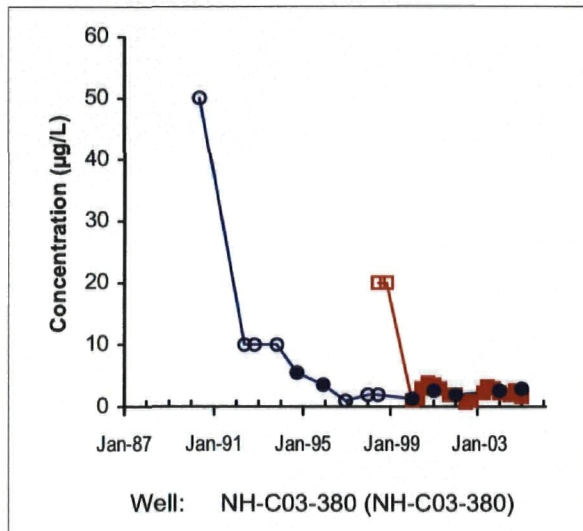
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Chromium Time Series Plots NORTH HOLLYWOOD



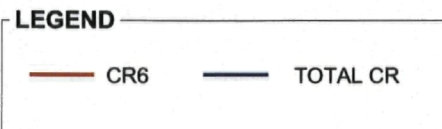
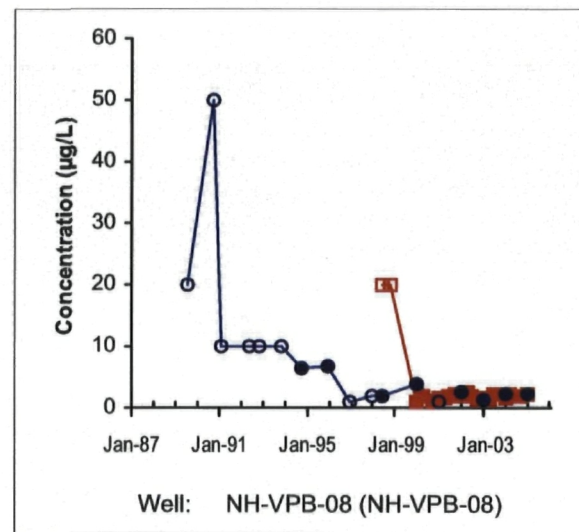
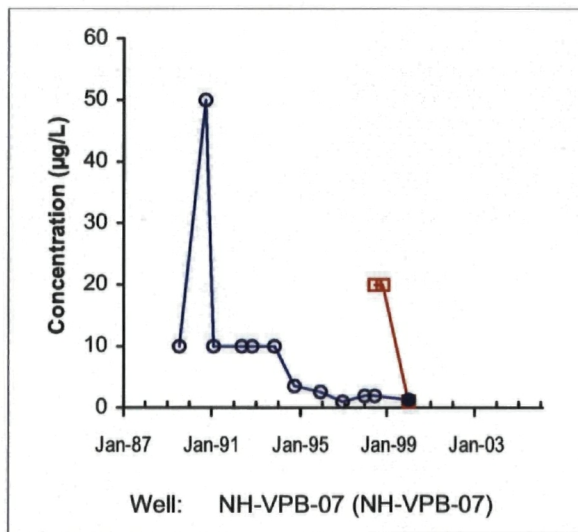
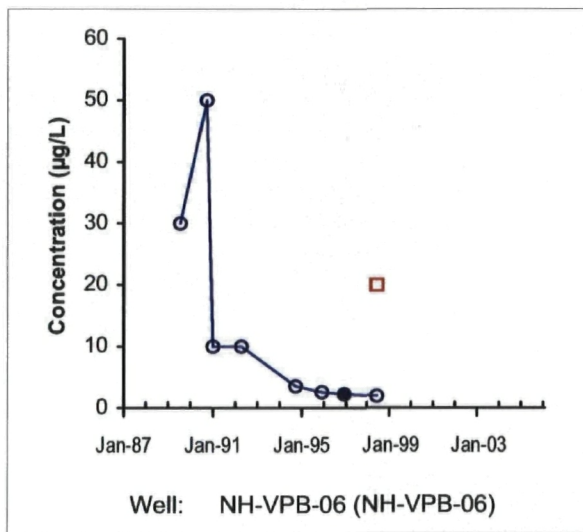
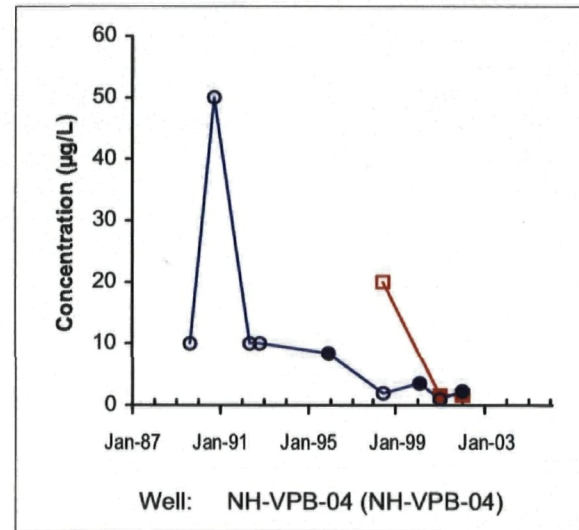
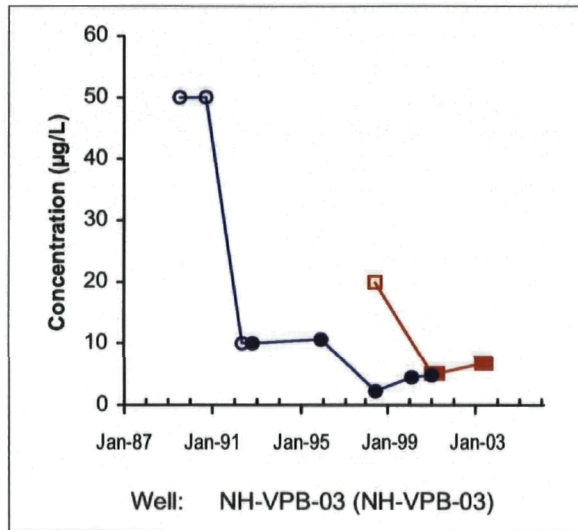
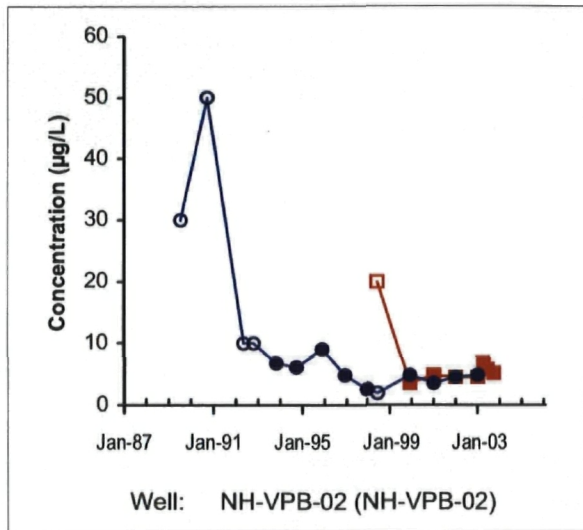
* Nondetects shown at MDL with open symbols

Chromium Time Series Plots NORTH HOLLYWOOD



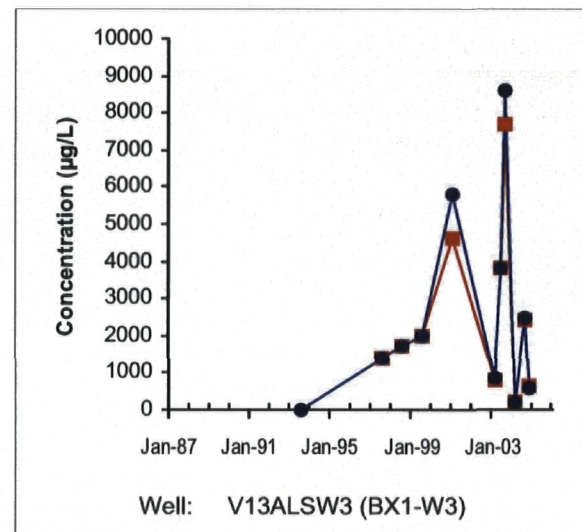
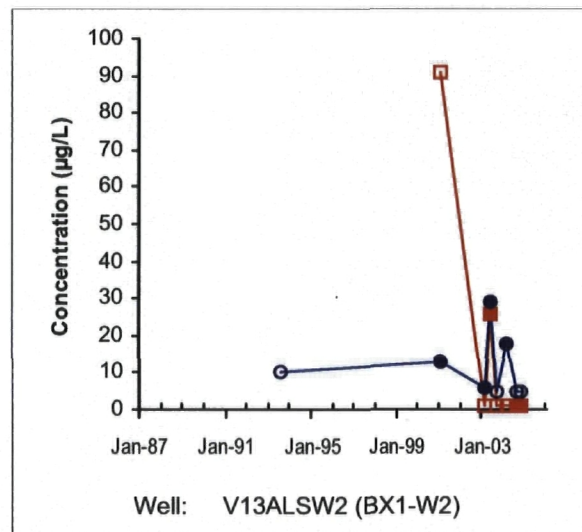
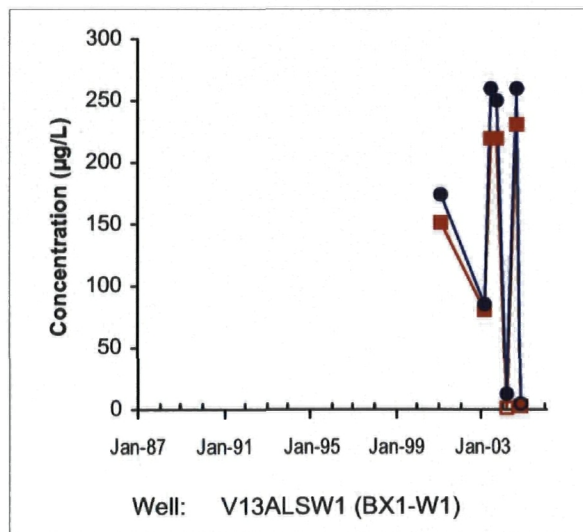
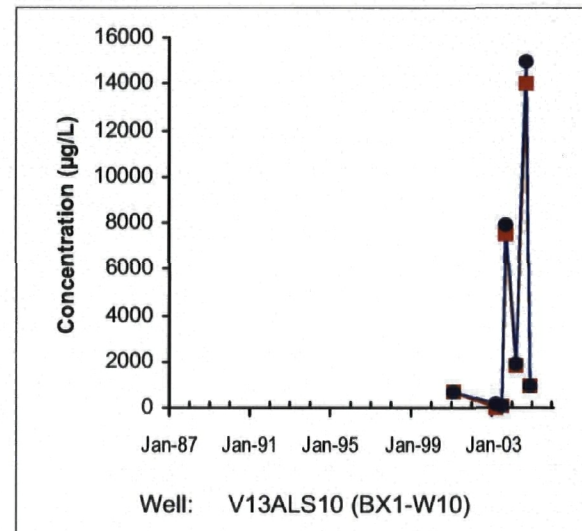
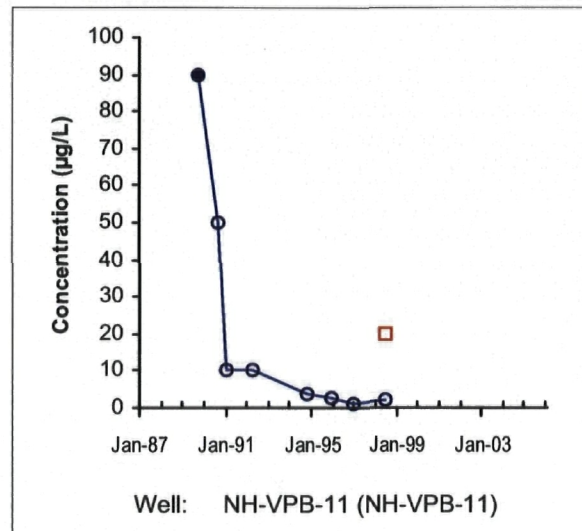
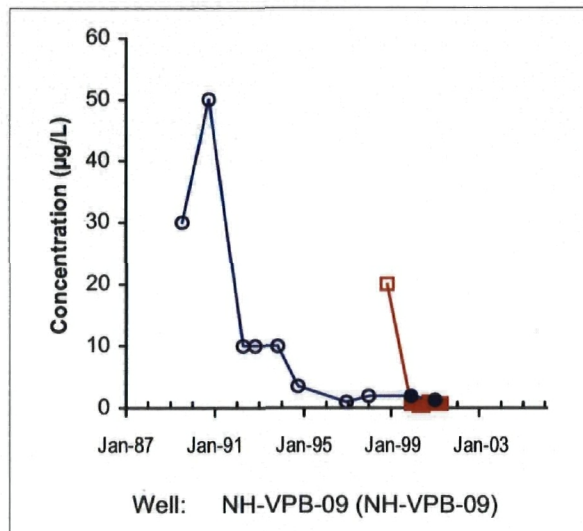
* Nondetects shown at MDL with open symbols

Chromium Time Series Plots NORTH HOLLYWOOD



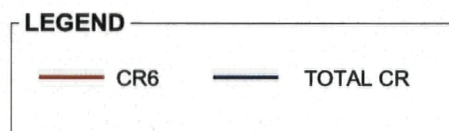
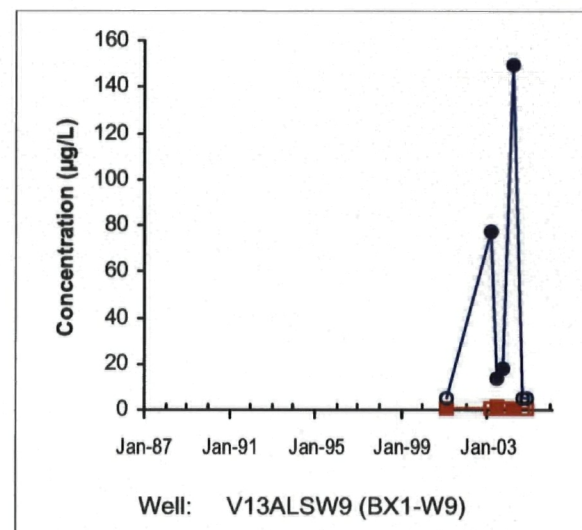
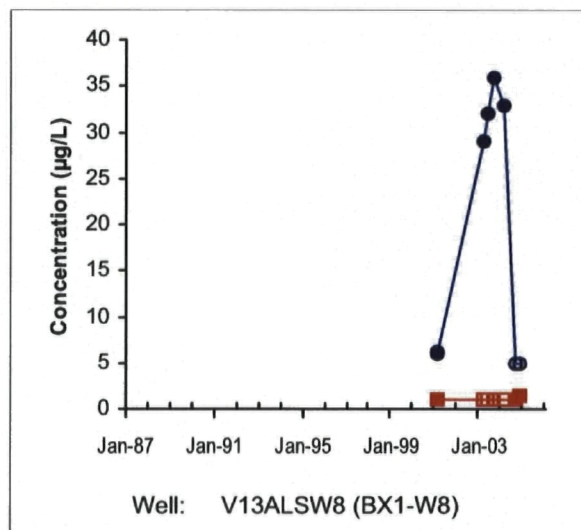
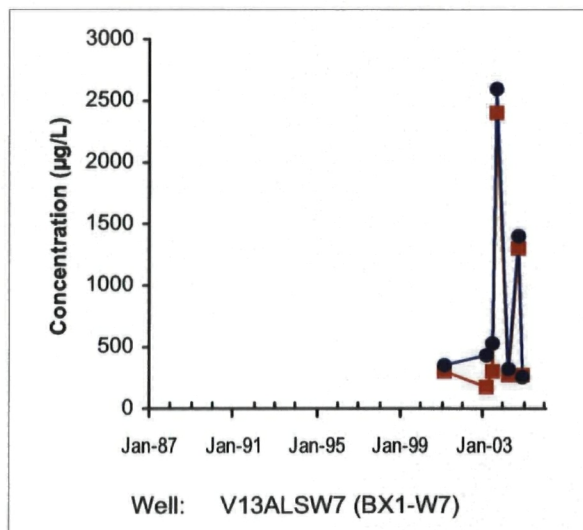
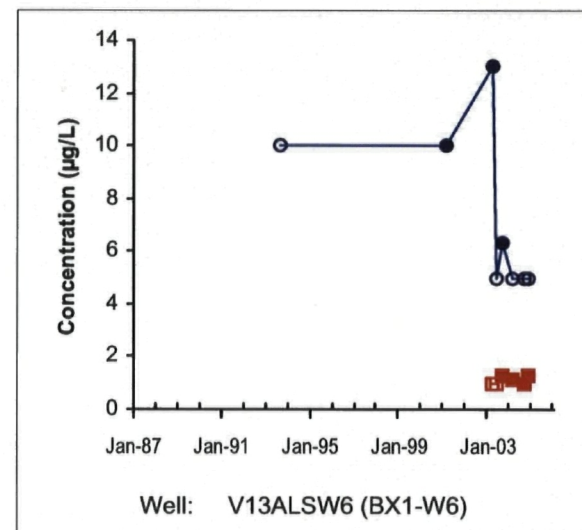
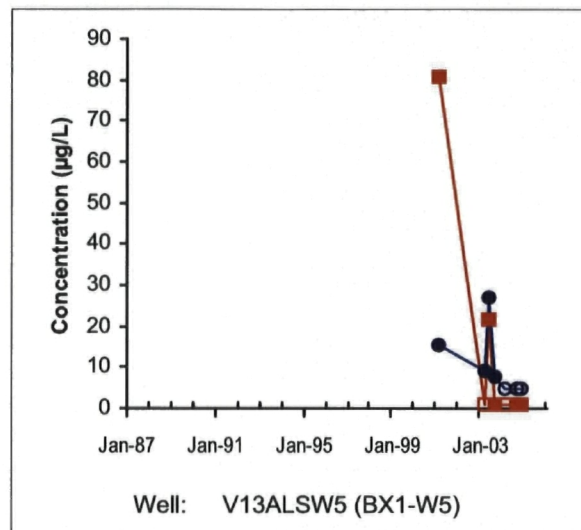
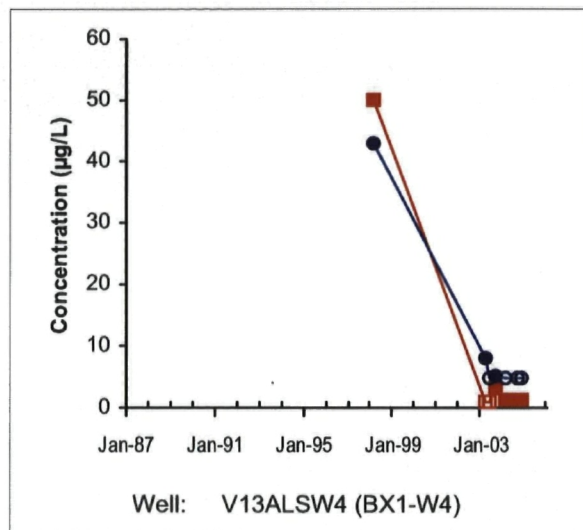
* Nondetects shown at MDL with open symbols

Chromium Time Series Plots NORTH HOLLYWOOD



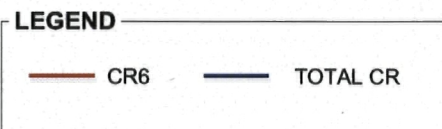
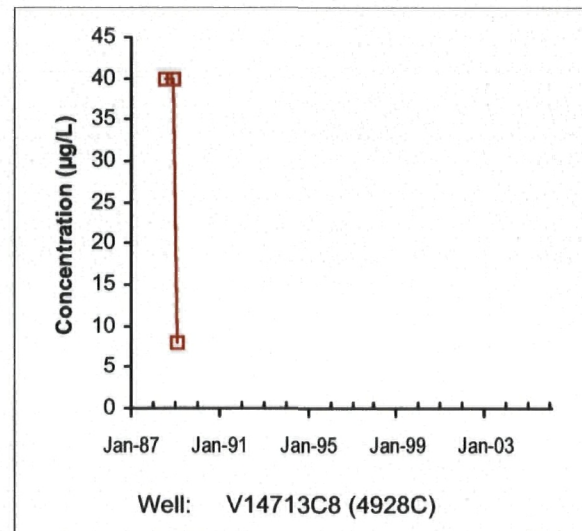
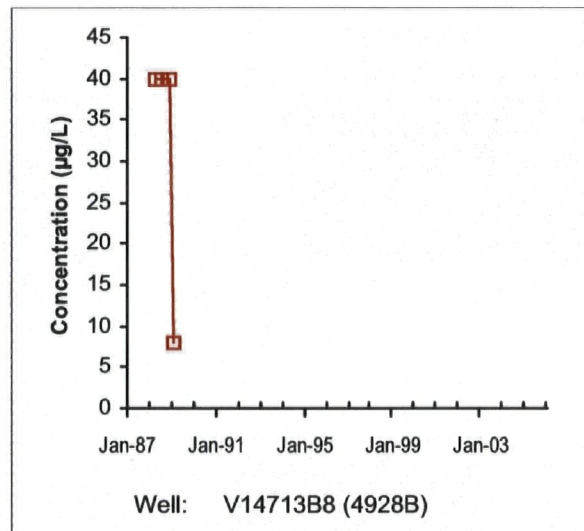
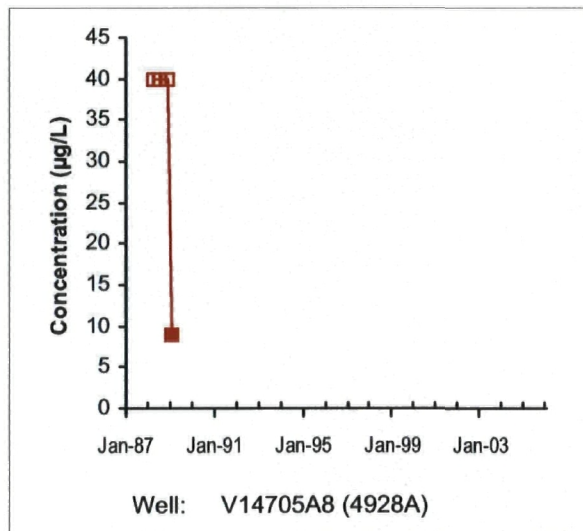
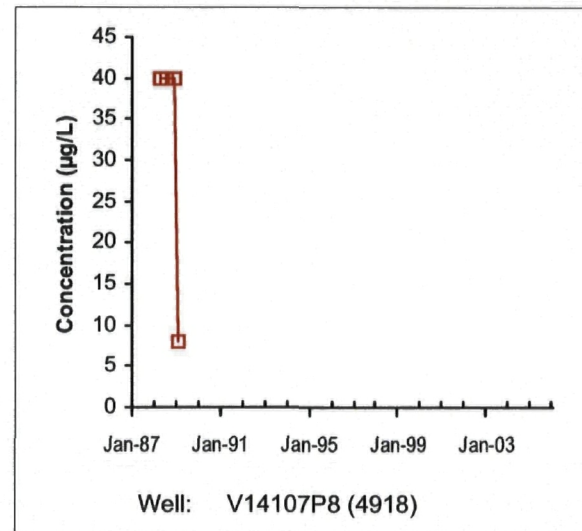
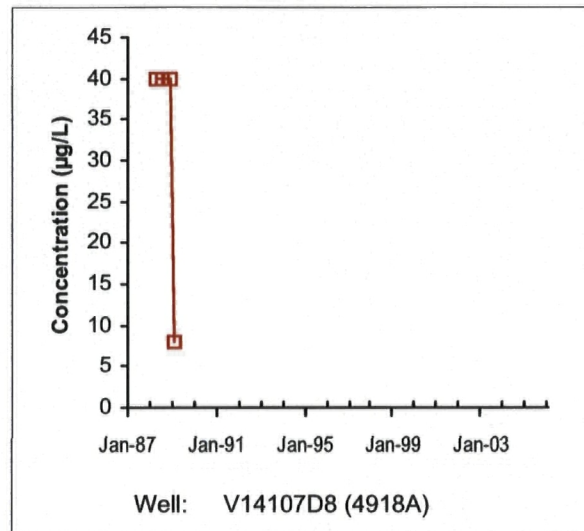
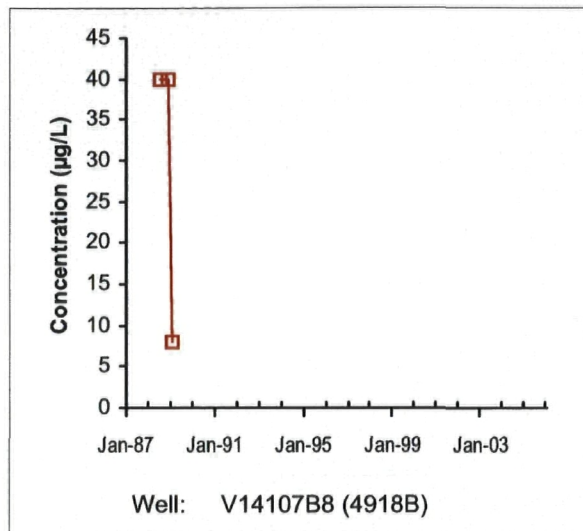
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Chromium Time Series Plots NORTH HOLLYWOOD



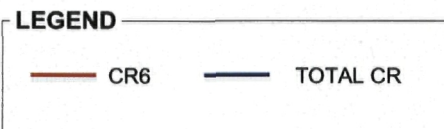
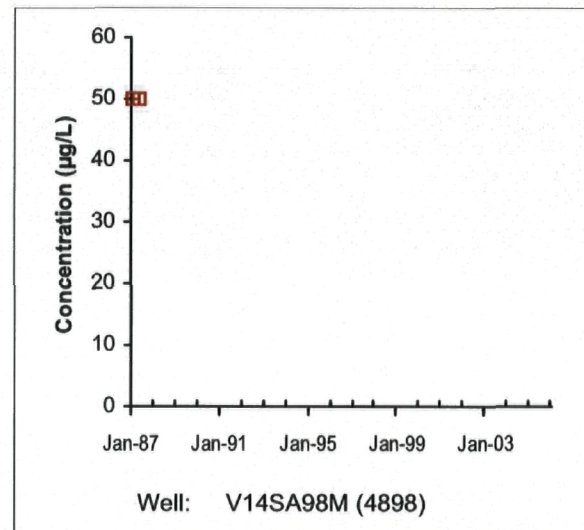
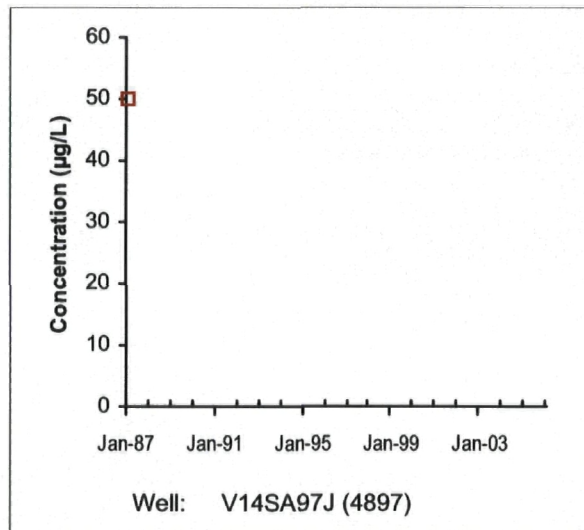
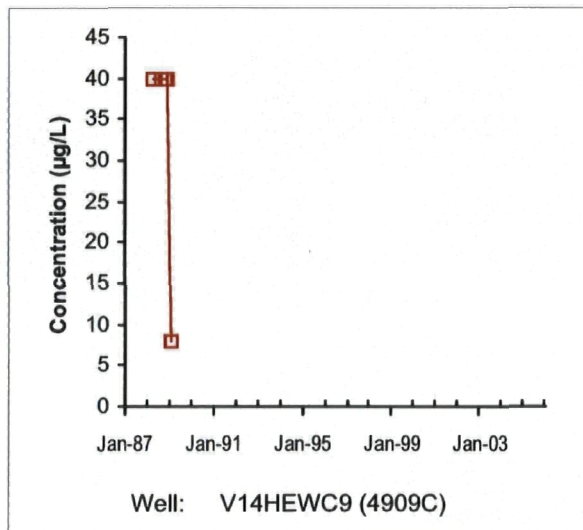
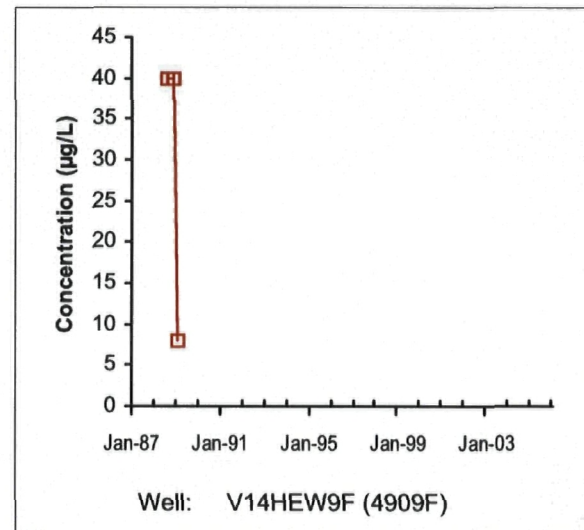
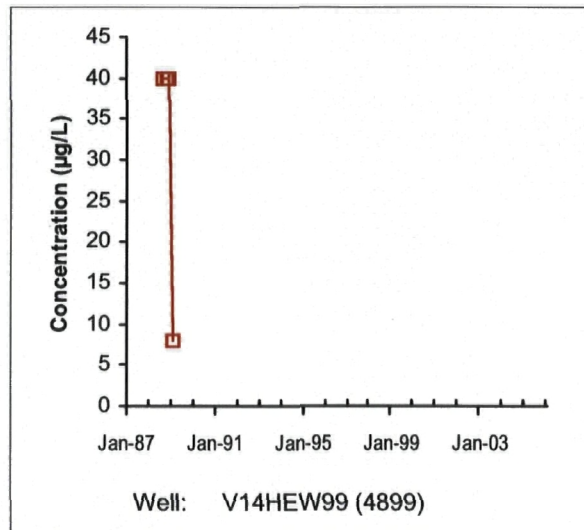
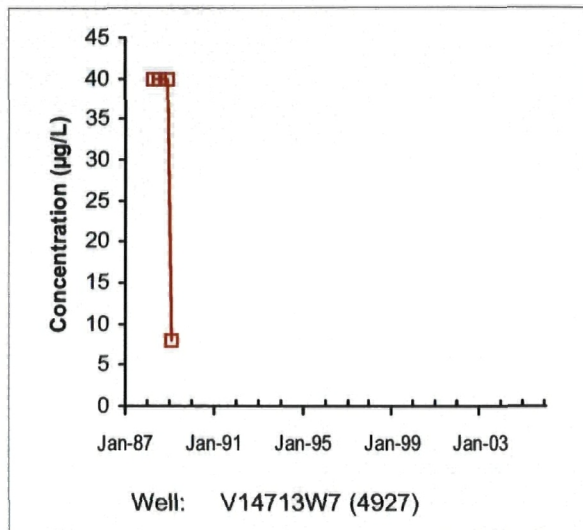
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Chromium Time Series Plots NORTH HOLLYWOOD



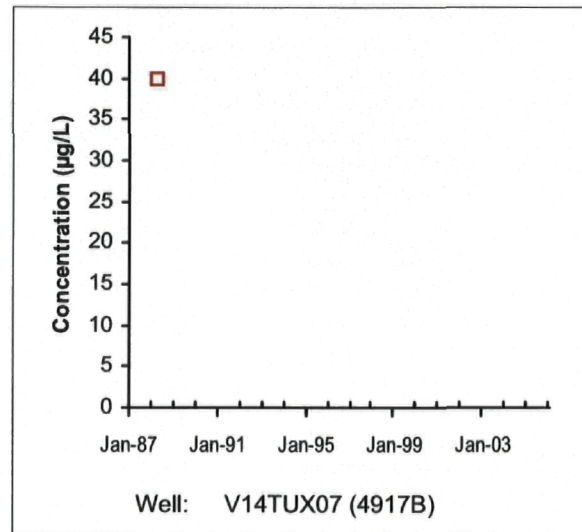
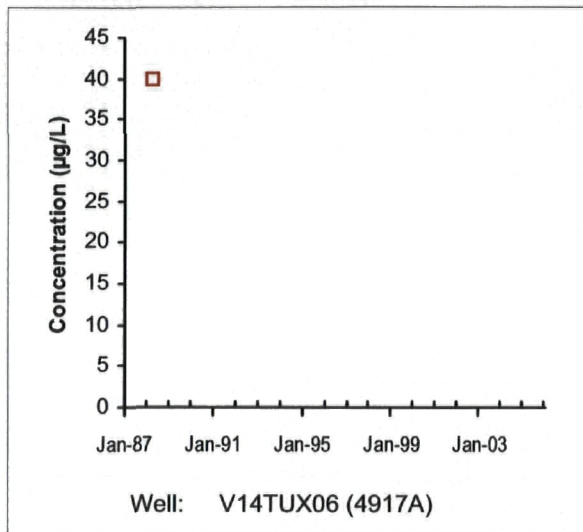
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Chromium Time Series Plots NORTH HOLLYWOOD



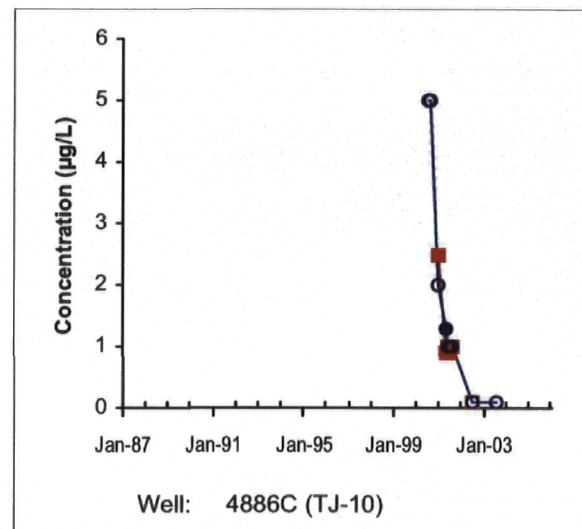
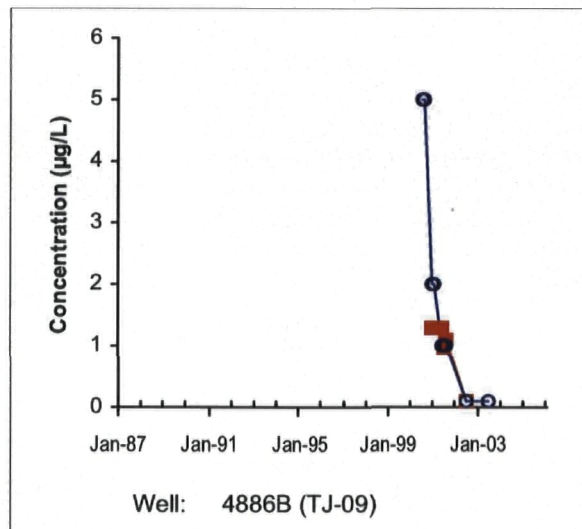
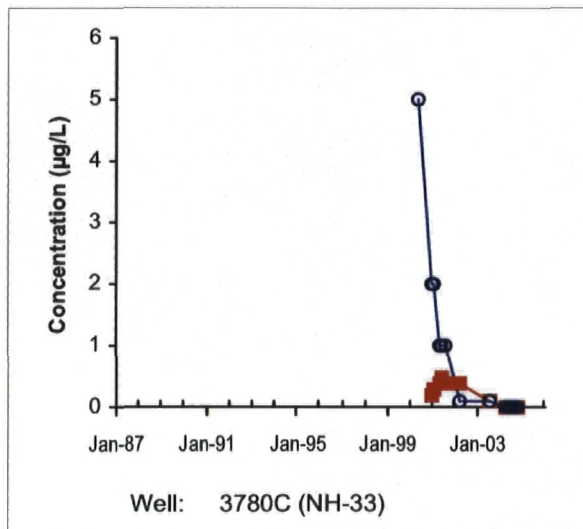
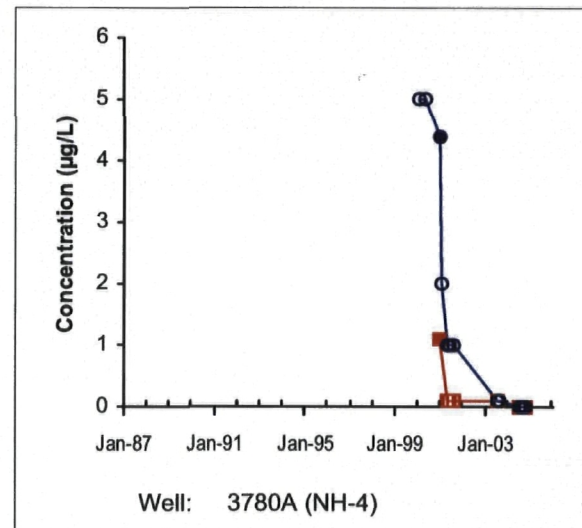
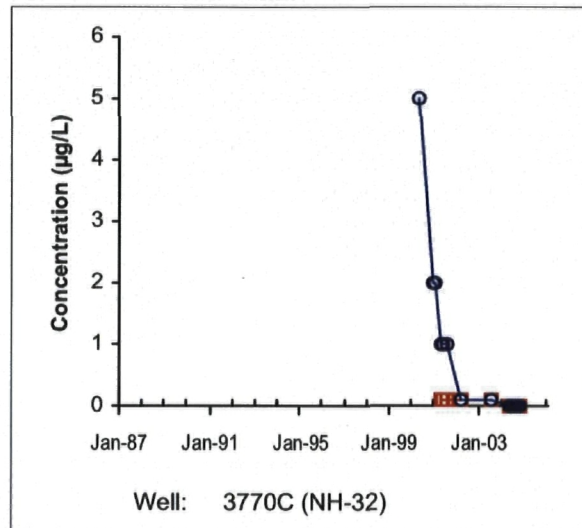
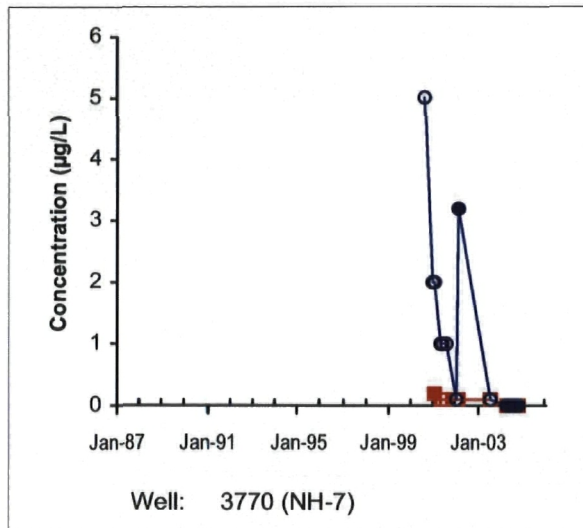
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Chromium Time Series Plots NORTH HOLLYWOOD



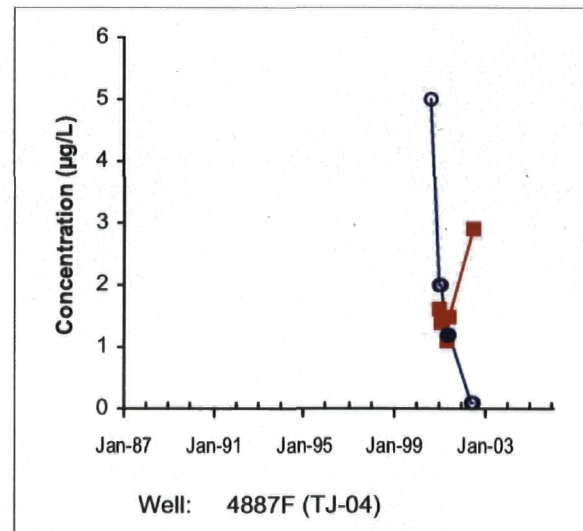
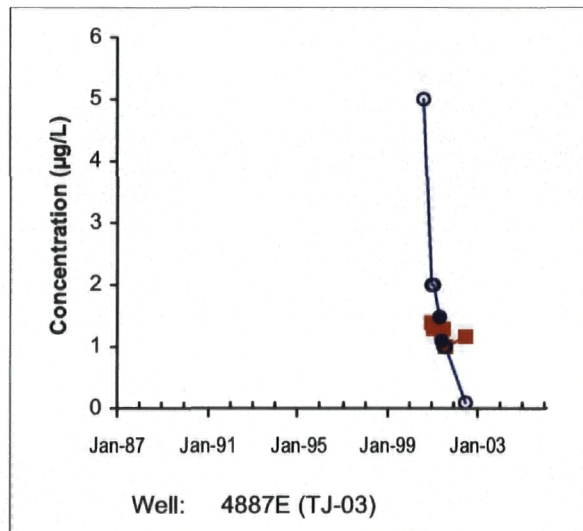
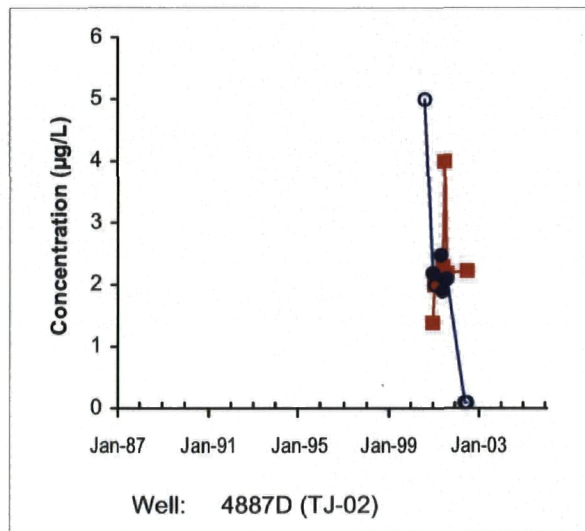
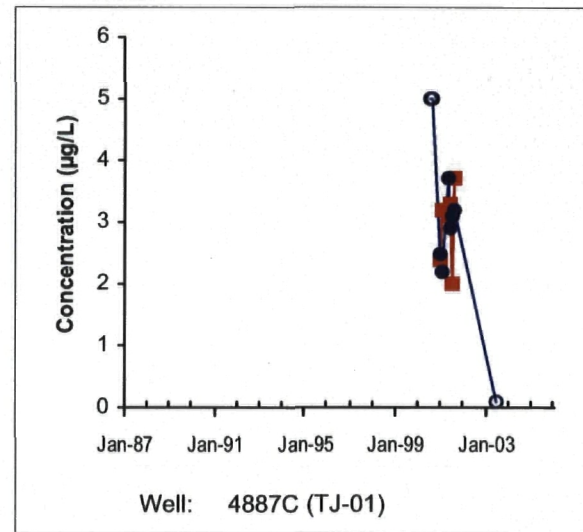
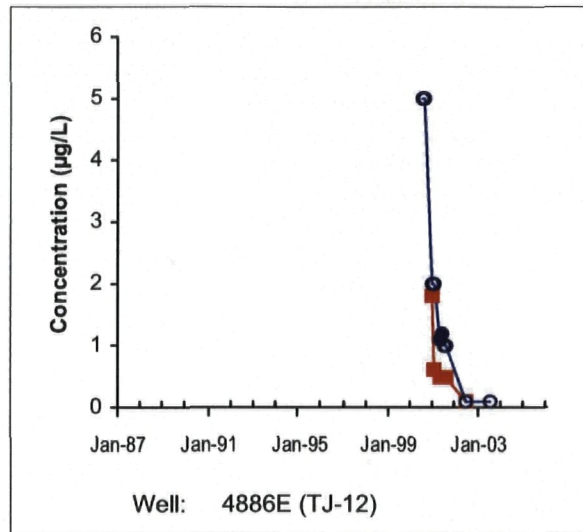
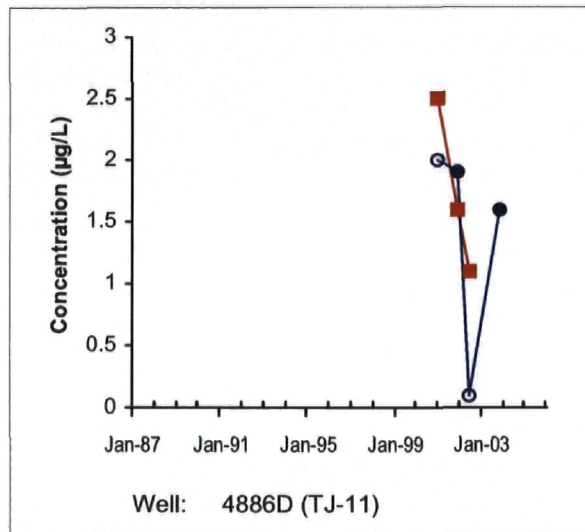
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Chromium Time Series Plots NORTH HOLLYWOOD



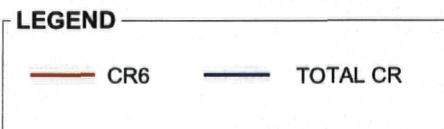
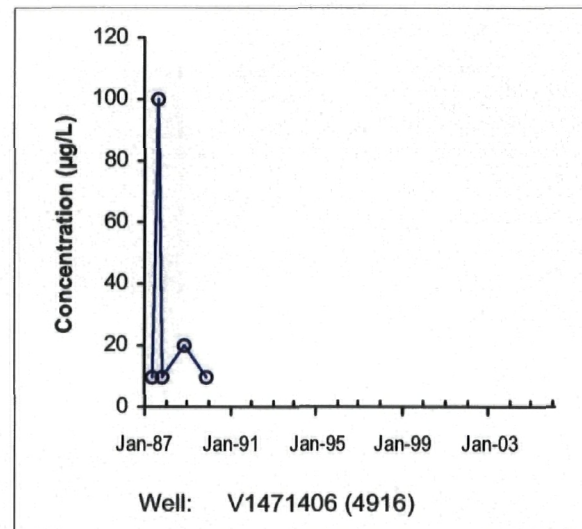
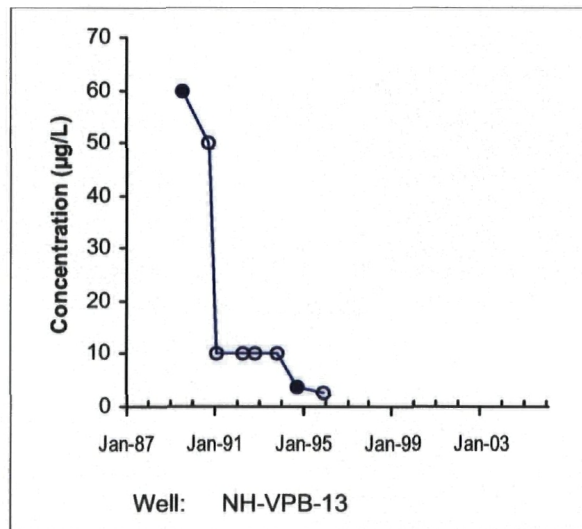
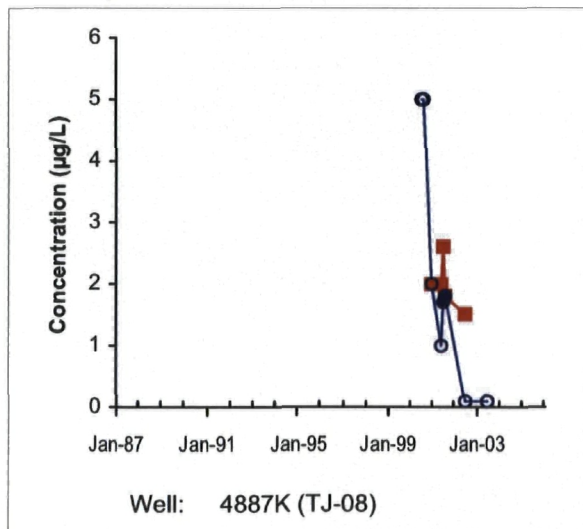
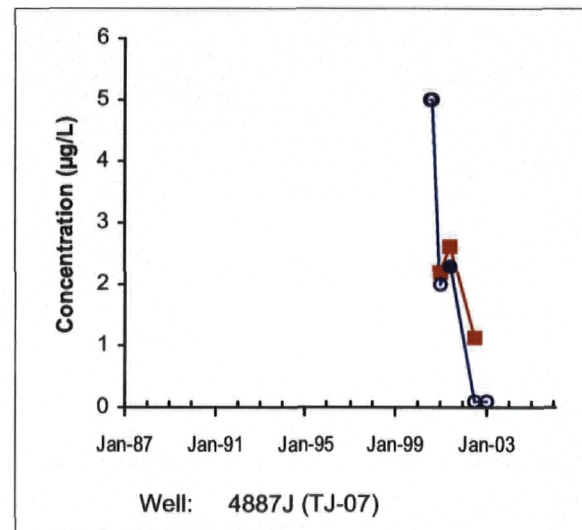
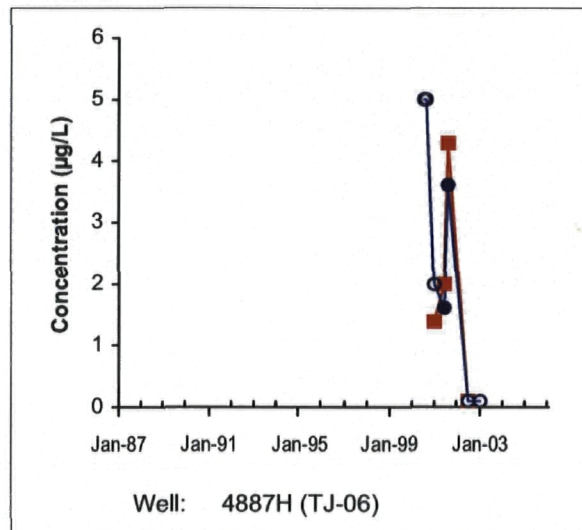
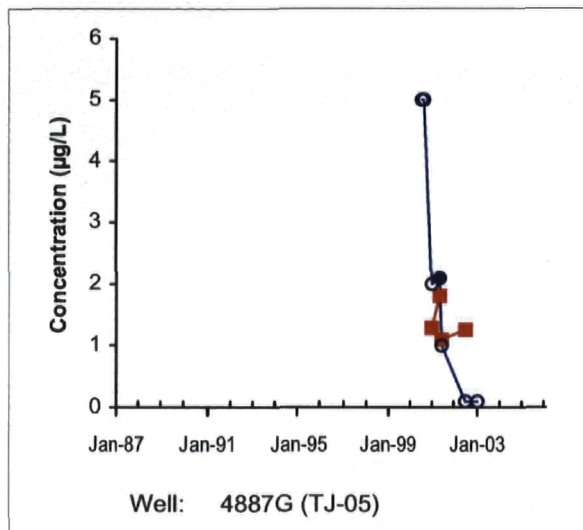
* Nondetects shown at MDL with open symbols

Chromium Time Series Plots OTHER



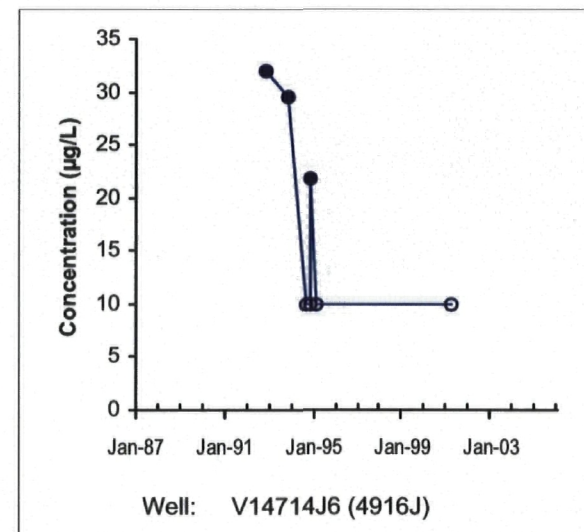
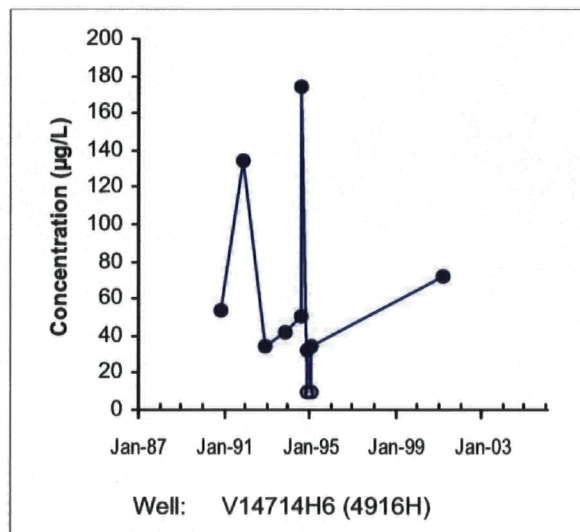
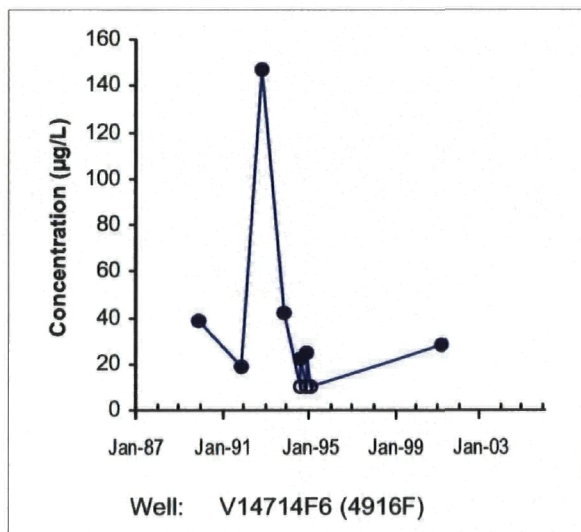
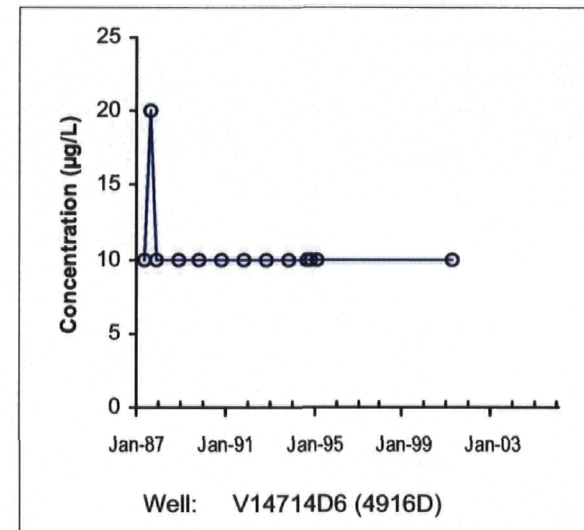
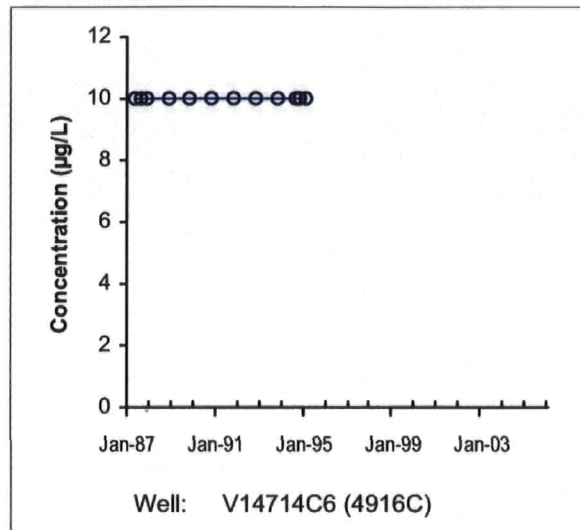
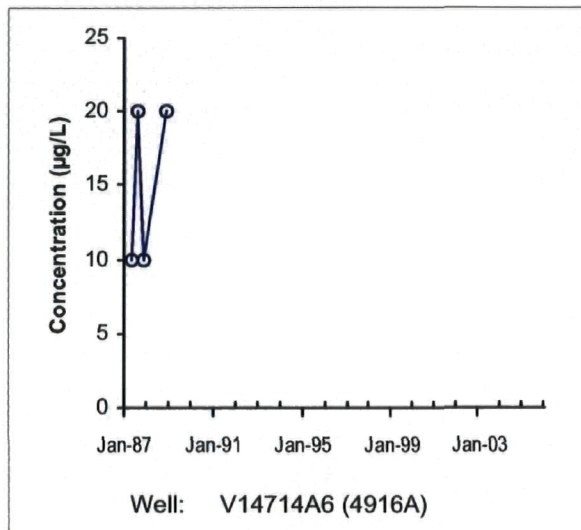
* Nondetects shown at MDL with open symbols

Chromium Time Series Plots OTHER



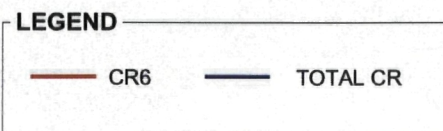
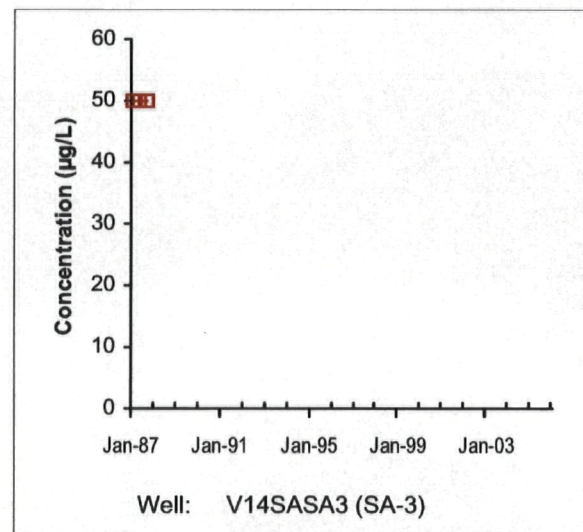
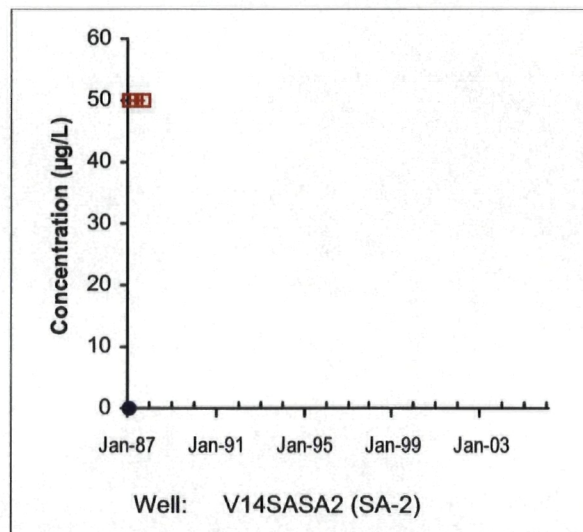
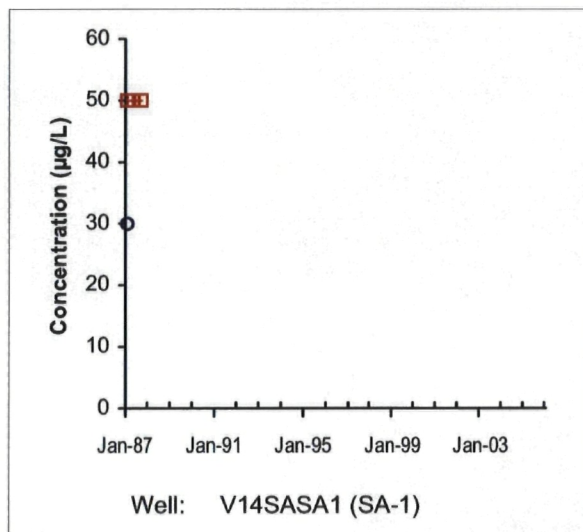
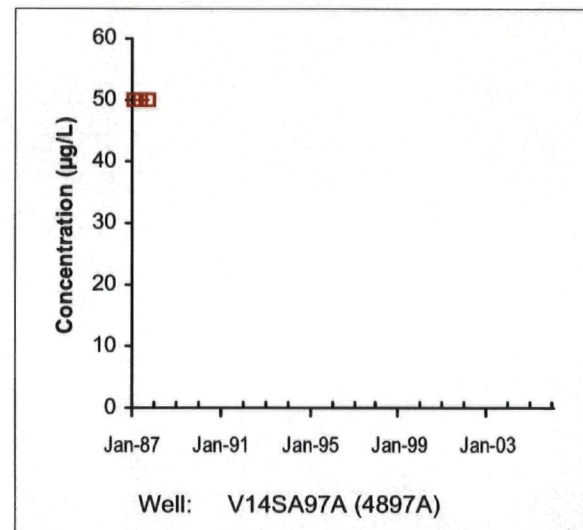
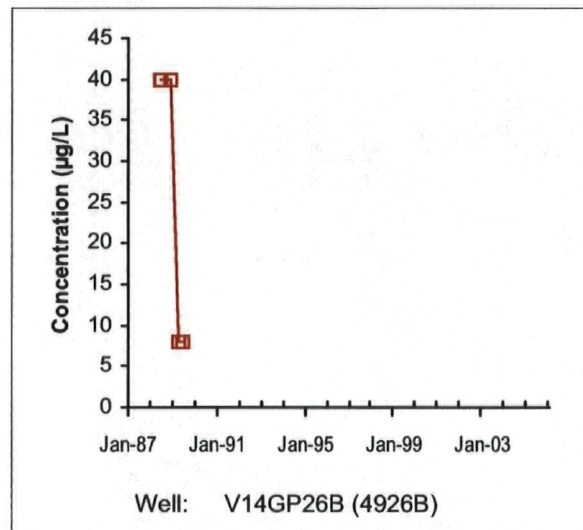
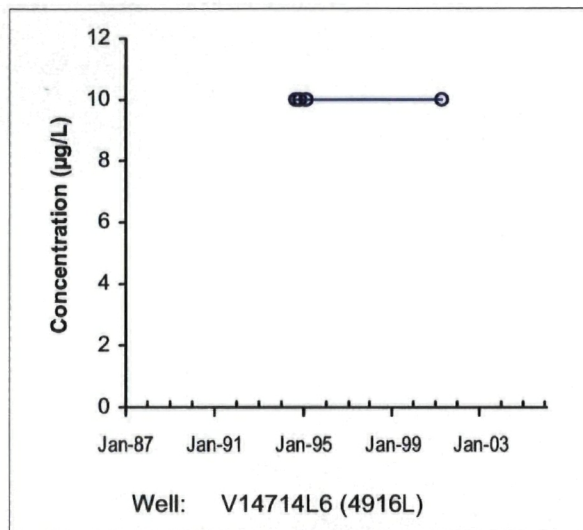
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Chromium Time Series Plots OTHER



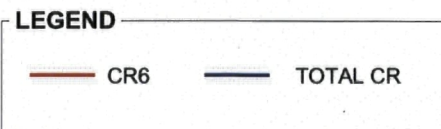
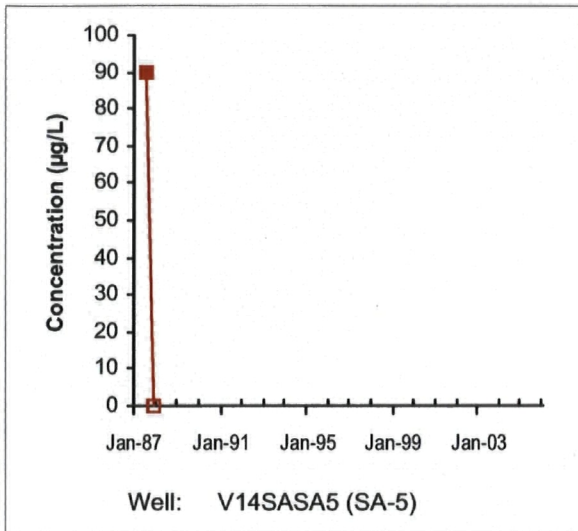
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Chromium Time Series Plots OTHER



* Nondetects shown at MDL with open symbols

Chromium Time Series Plots OTHER



* Nondetects shown at MDL with open symbols

Chromium Time Series Plots OTHER